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Drawing Details: The Good, The Bad, & The Ugly

May 13, 2021



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Stronger.
Steel.**

AISC Live Webinars

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AISC Live Webinars

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AISC Live Webinars

Course Description

Drawing Details: The Good, The Bad, and The Ugly
May 13, 2021

All contract documents have details to convey information, but not all details are created equal. This webinar will review examples of drawing details for clarity and simplification, identify issues such as load path, and explore potential corrections to bad details.



AISC Live Webinars

Learning Objectives

- List features of a good structural steel drawing detail.
- Identify examples of structural details that do not provide valid load paths.
- Describe some common problems with connections to hollow structural sections and how they might be avoided.
- Demonstrate the value of drawing conceptual details with realistic geometry.



Drawing Details: The Good, The Bad, and The Ugly



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Webinar Outline

- Introduction
- Define Good, Bad, Ugly Details
- Examples
- Tips for Better Details & Connections
- Assessment and Q/A



Webinar Outline

- **Introduction**
- **Define Good, Bad, Ugly Details**
- **Examples**
- **Tips for Better Details & Connections**
- **Assessment and Q/A**



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Drawing Details: The Good, The Bad, and The Ugly

Connections are essential to steel-framed structures

- Connect framing members to one another
 - Allow loads to transfer between members
 - Provide a complete load path to the foundation
- Drawing details need to accurately show how this is accomplished
 - Does new technology help or hurt?



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Webinar Outline

- Introduction
- **Define Good, Bad, Ugly Details**
- Examples
- Tips for Better Details & Connections
- Assessment and Q/A



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Drawing Details: The Good

What makes a *good* detail?

- Valid load path
- Satisfies all limit states
- Easy to fabricate
- Easy to install
- Economical

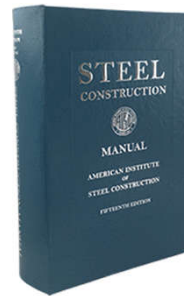


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Drawing Details: The Good

Where to find examples of good details:

- AISC Manual Parts 9 – 14



Drawing Details: The Good

Where to find examples of good details:

- AISC Manual Parts 9 – 14
- AISC Design Examples



Drawing Details: The Good

Where to find examples of good details:

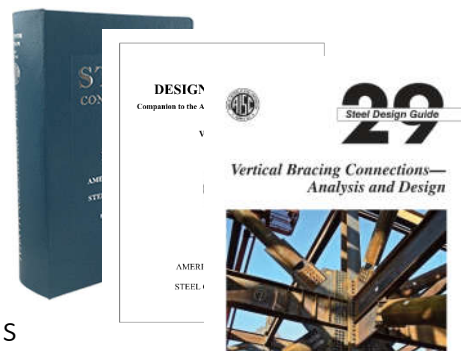
- AISC Manual Parts 9 – 14
- AISC Design Examples
- AISC Design Guides
 - Design Guide 4 – Moment Connections
 - Design Guide 29 – Vertical Bracing Connections



Drawing Details: The Good

Where to find examples of good details:

- AISC Manual Parts 9 – 14
- AISC Design Examples
- AISC Design Guides
 - Design Guide 4 – Moment Connections
 - Design Guide 29 – Vertical Bracing Connections
- Numerous textbooks and other publications



Drawing Details: The Bad

What makes a *bad* detail?

- Invalid load path
- Limit state(s) are exceeded



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Drawing Details: The Ugly

What makes an *ugly* detail?

- Valid load path
- Satisfies all limit states
- Not easily fabricated and/or installed
 - Typically a result of
 - Geometry
 - Member selection
- Not economical
 - Typically a result of overly restrictive design requirements and limitations shown on the design drawings



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Drawing Details: Bad vs. Ugly

- Bad Details
 - ***Must*** be avoided
 - Life-safety issue
- Ugly Details
 - Sometimes cannot be avoided
 - Work with all parties involved (EOR, connection engineer, fabricator, erector, etc.) to find the ***best*** solution



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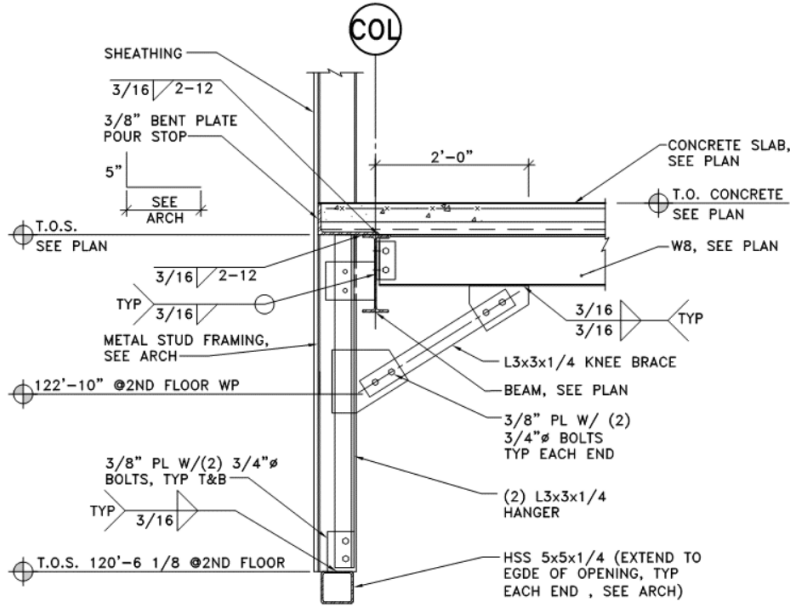
Webinar Outline

- Introduction
- Define Good, Bad, Ugly Details
- **Examples**
- Tips for Better Details & Connections
- Assessment and Q/A

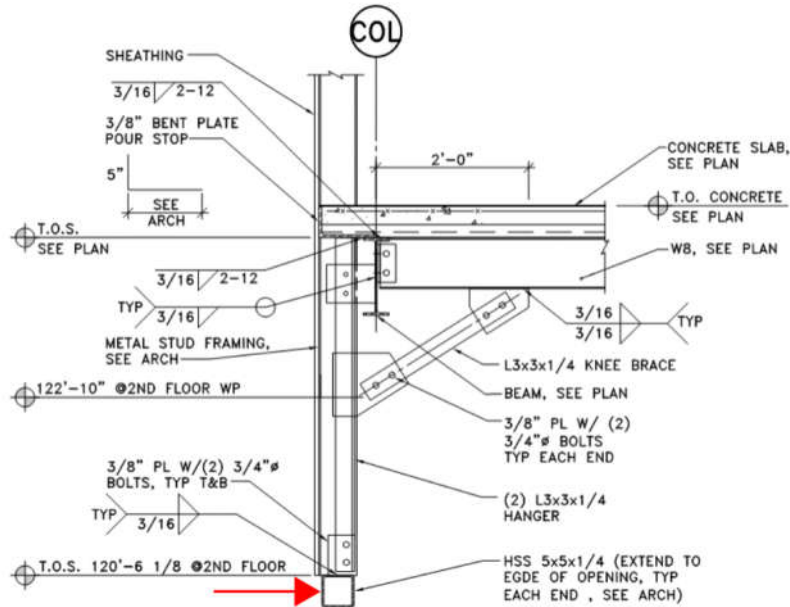


20

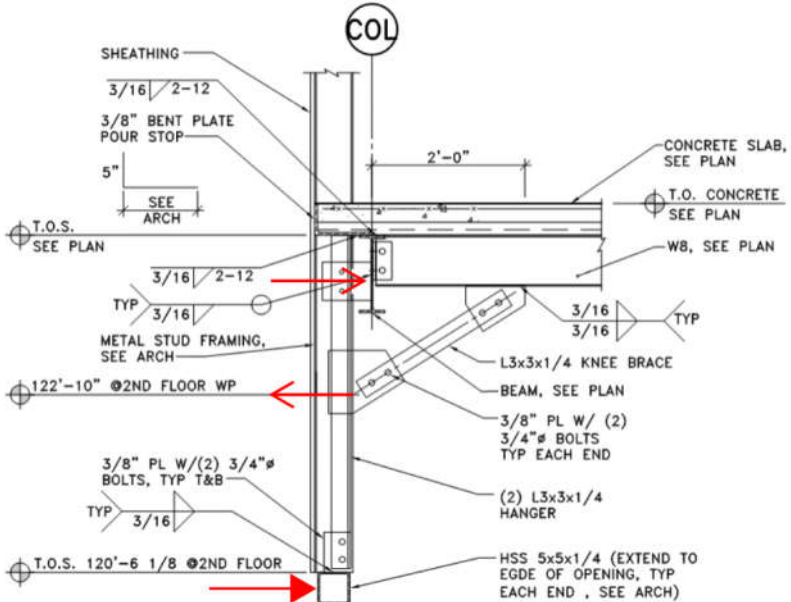
Drawing Details: Example 1



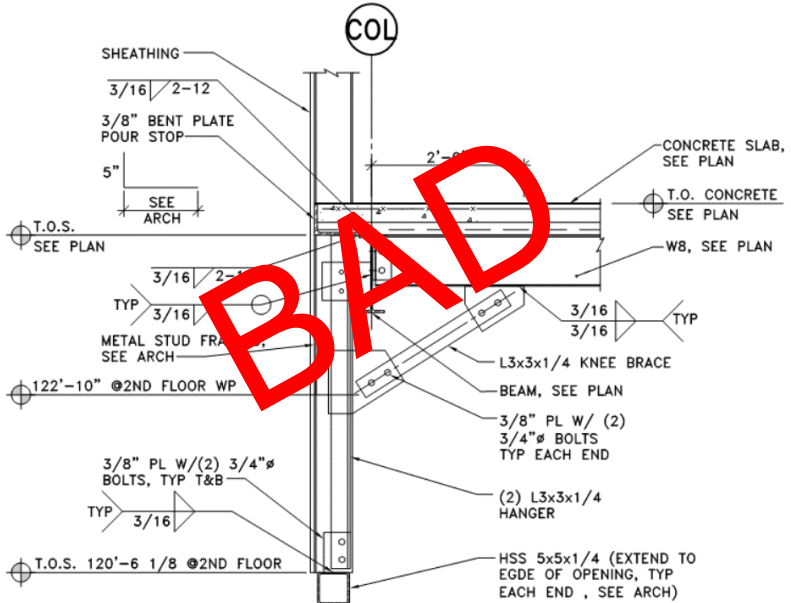
Drawing Details: Example 1



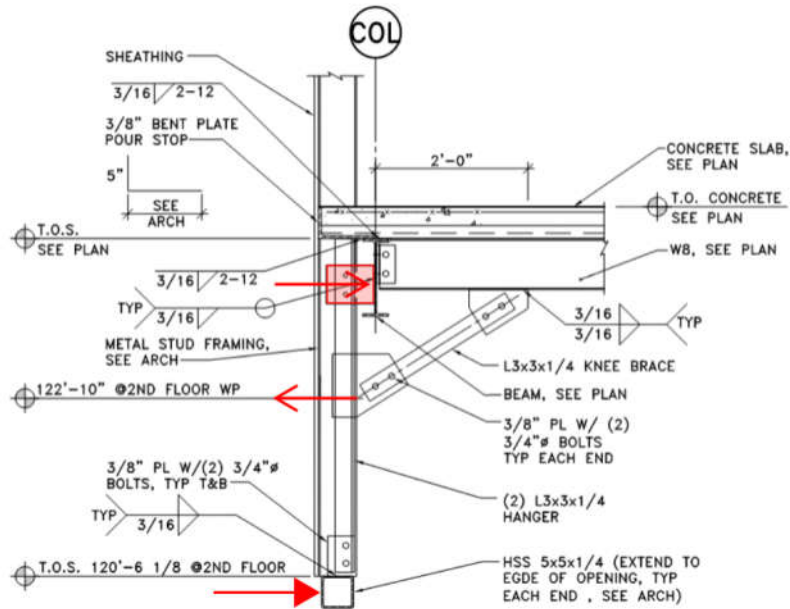
Drawing Details: Example 1



Drawing Details: Example 1

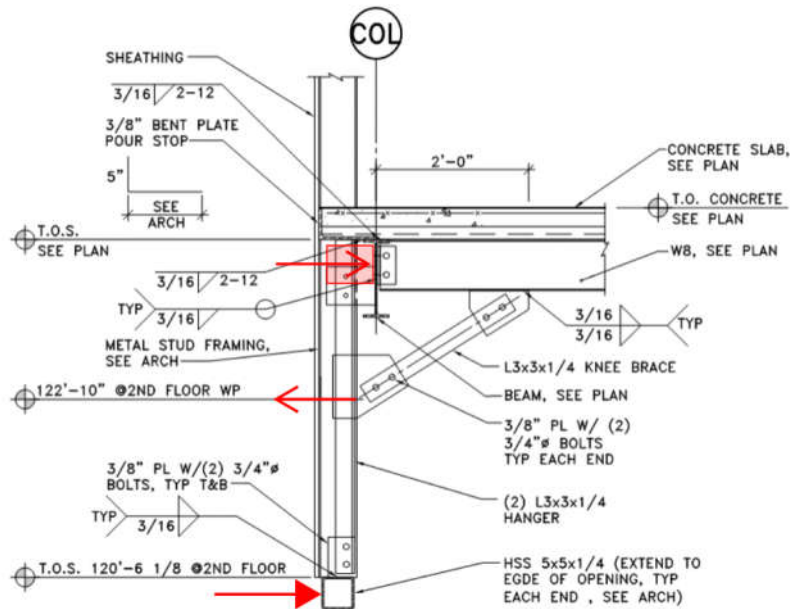


Drawing Details: Example 1



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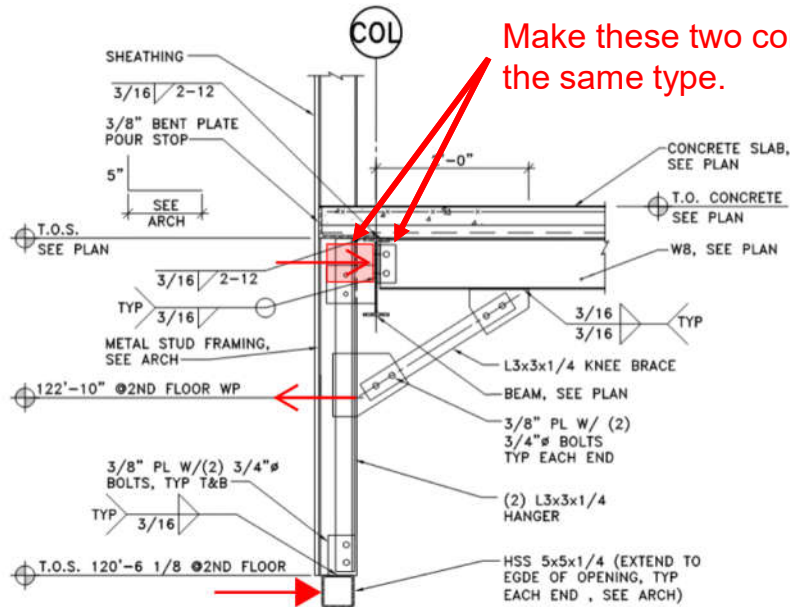
Drawing Details: Example 1



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Drawing Details: Example 1



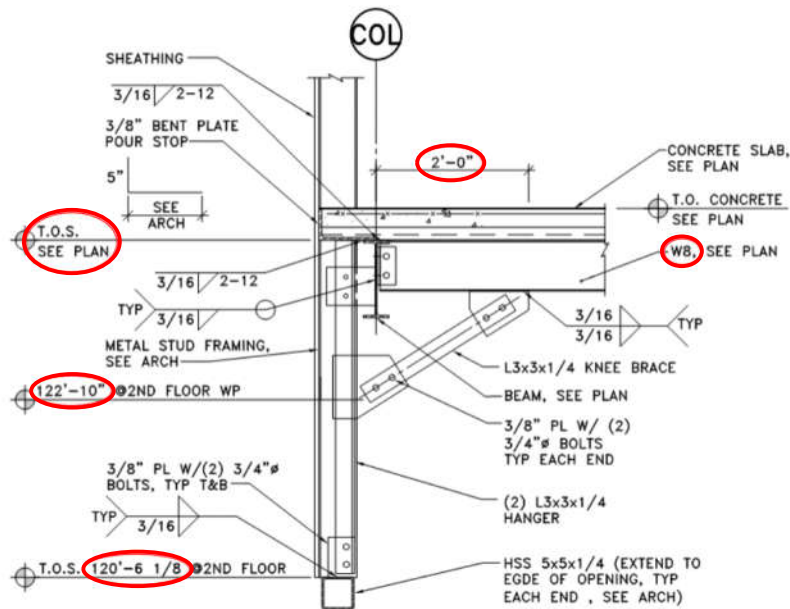
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Drawing Details: Example 1

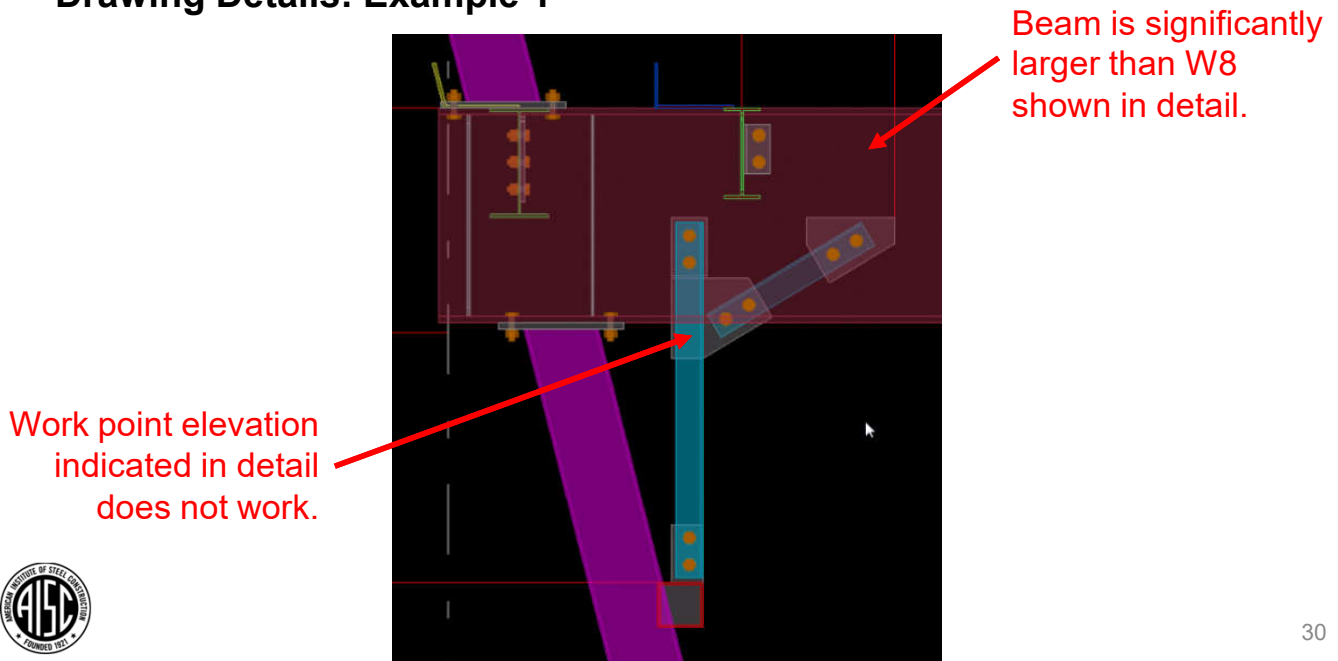
But there is more to this detail...

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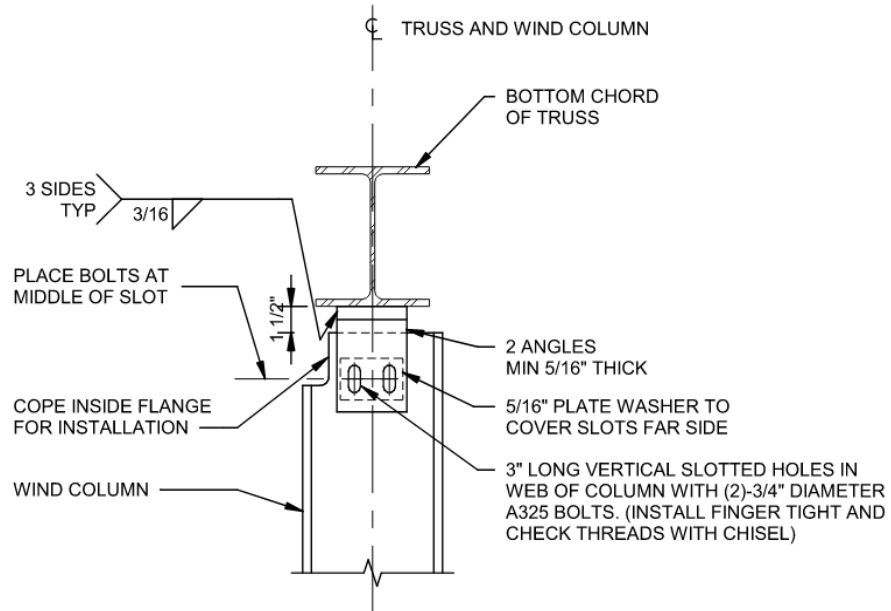
Drawing Details: Example 1



Drawing Details: Example 1



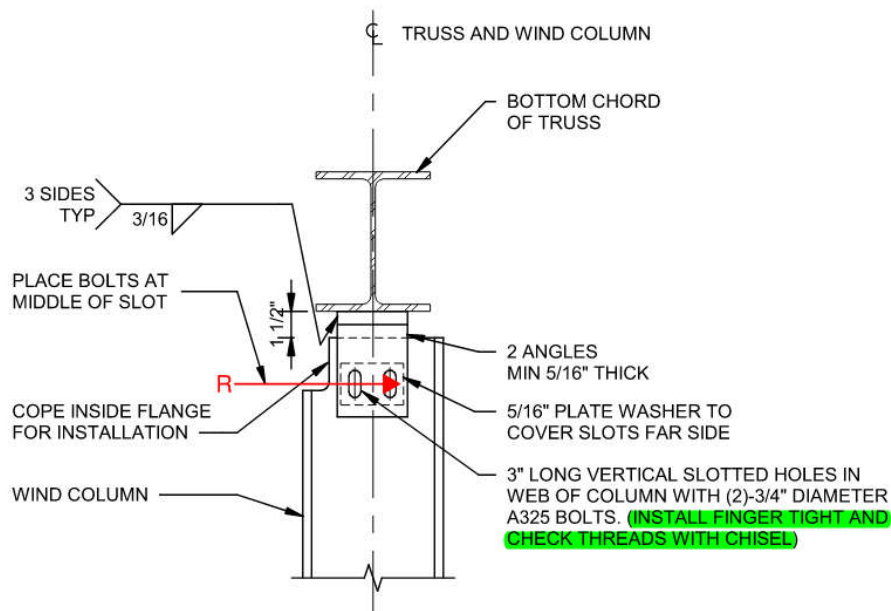
Drawing Details: Example 2



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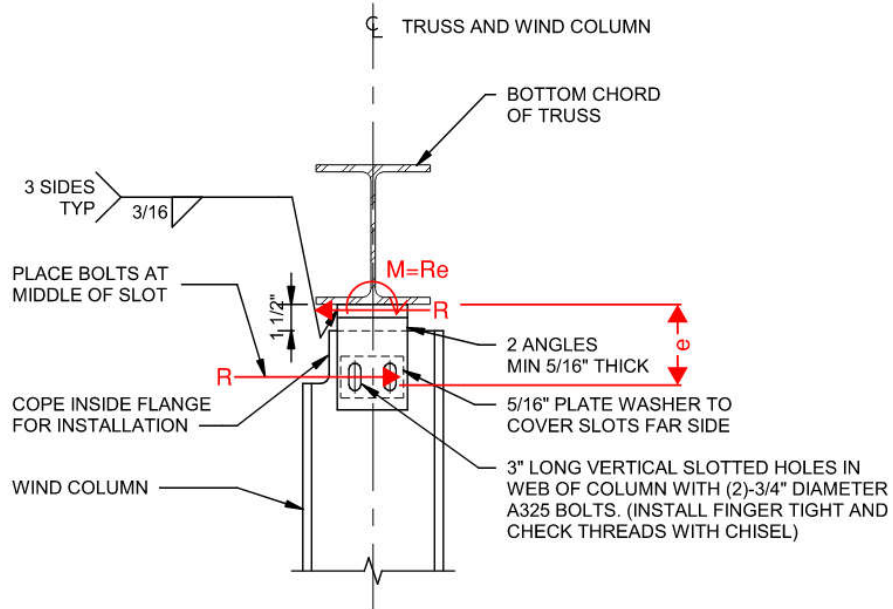
Drawing Details: Example 2



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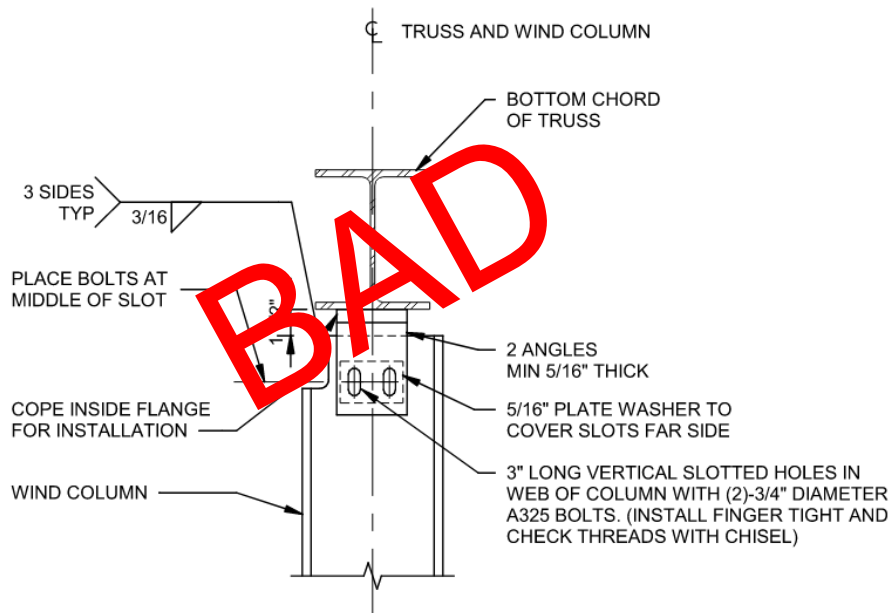


Drawing Details: Example 2



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Drawing Details: Example 2



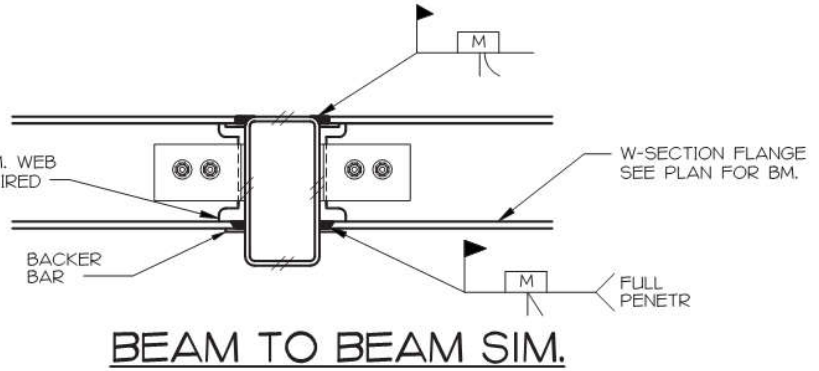
34



Drawing Details: Example 3

Per *Specification* Section B3.4b:

An FR connection shall have sufficient **strength** and **stiffness** to maintain the initial angle between the connected members at the strength limit state.

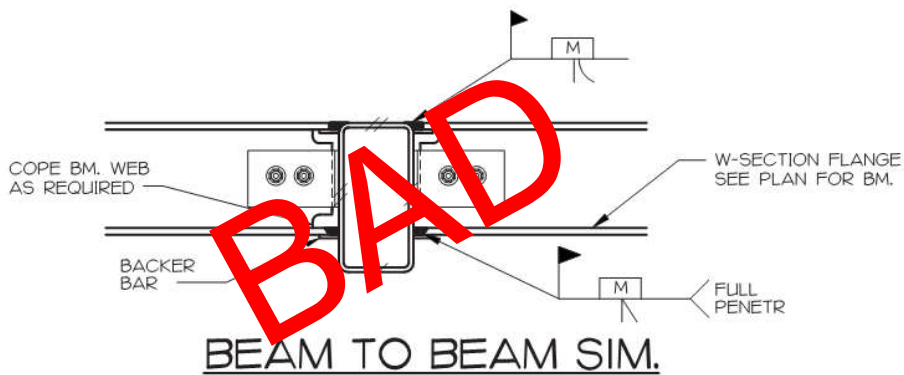


5
 S5
 3/4" = 1'-0"

TYPICAL MOMENT CONNECTION



Drawing Details: Example 3



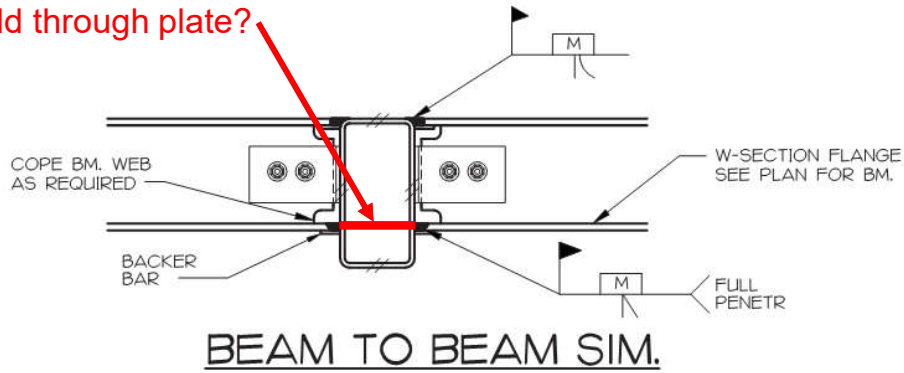
5
 S5
 3/4" = 1'-0"

TYPICAL MOMENT CONNECTION



Drawing Details: Example 3

Add through plate?



5
S5

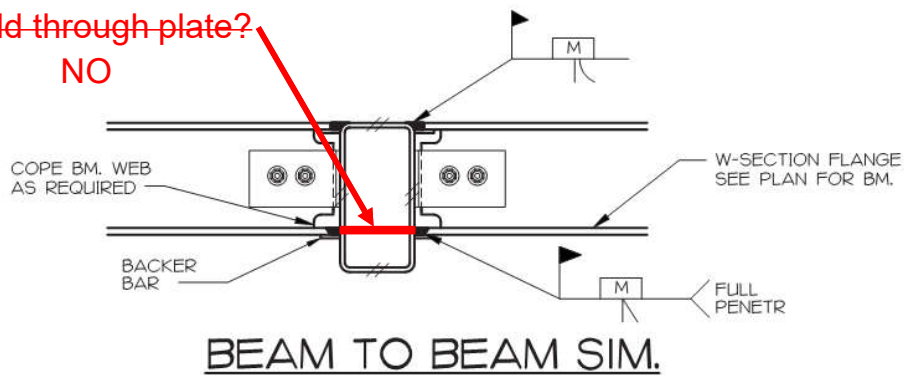
TYPICAL MOMENT CONNECTION

$\frac{3}{4}'' = 1'-0''$



Drawing Details: Example 3

Add through plate?
NO



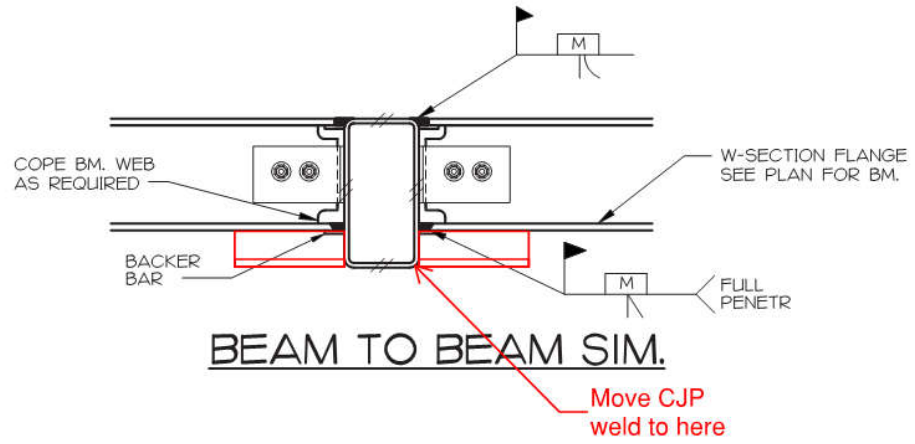
5
S5

TYPICAL MOMENT CONNECTION

$\frac{3}{4}'' = 1'-0''$



Drawing Details: Example 3



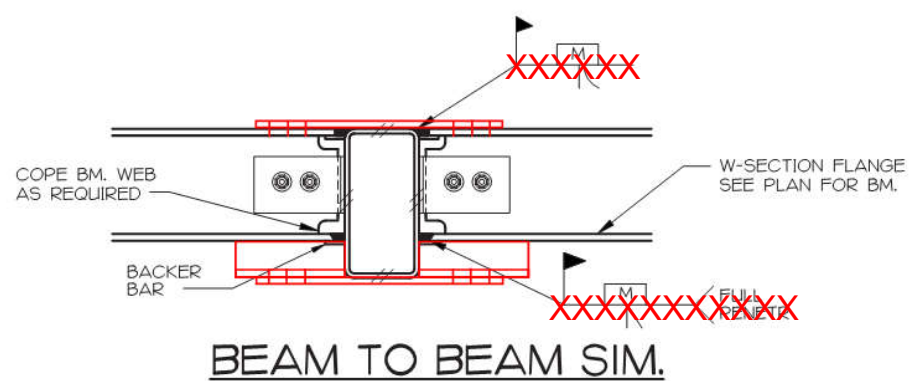
5
S5

TYPICAL MOMENT CONNECTION

$\frac{3}{4}'' = 1'-0''$



Drawing Details: Example 3



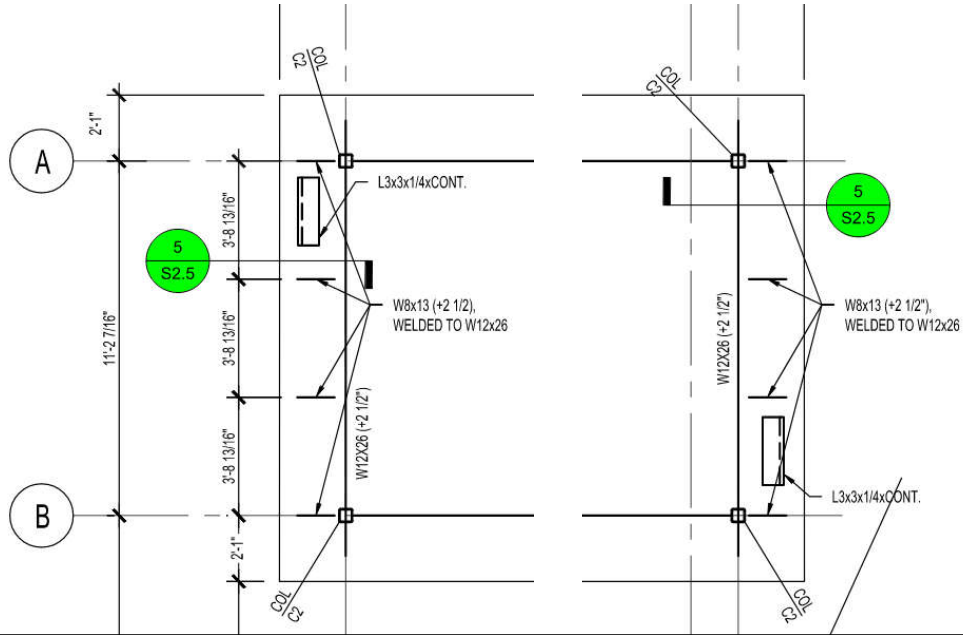
5
S5

TYPICAL MOMENT CONNECTION

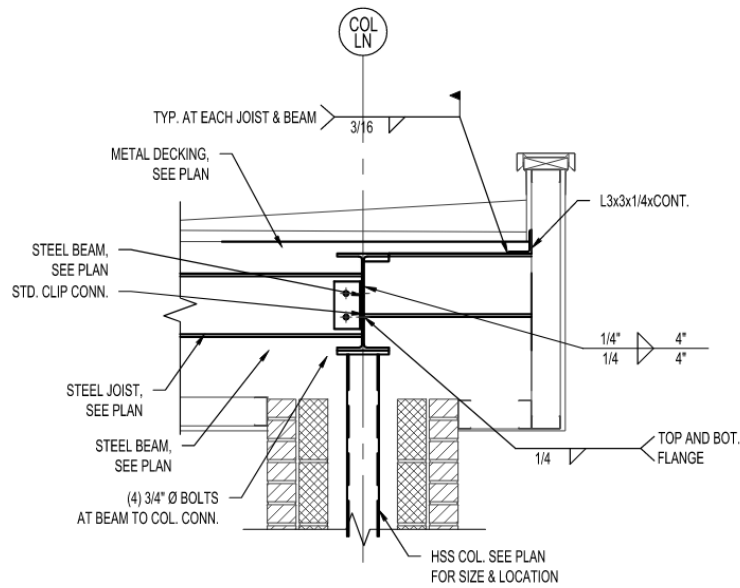
$\frac{3}{4}'' = 1'-0''$



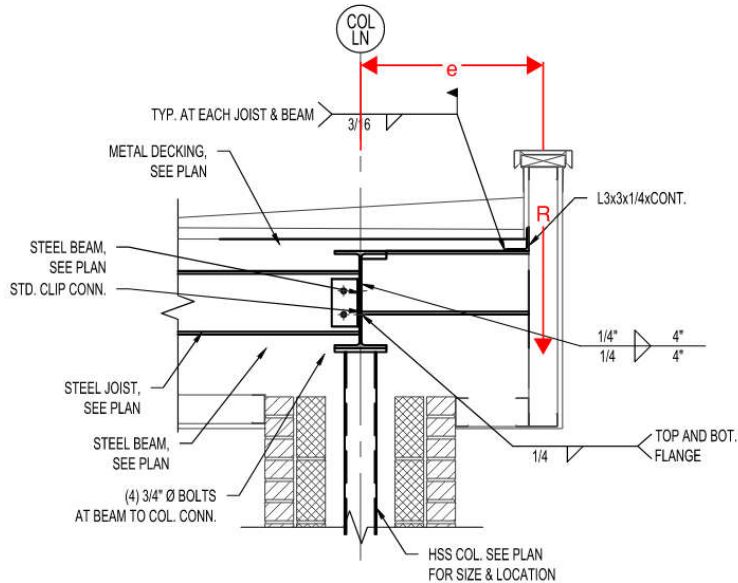
Drawing Details: Example 4



Drawing Details: Example 4

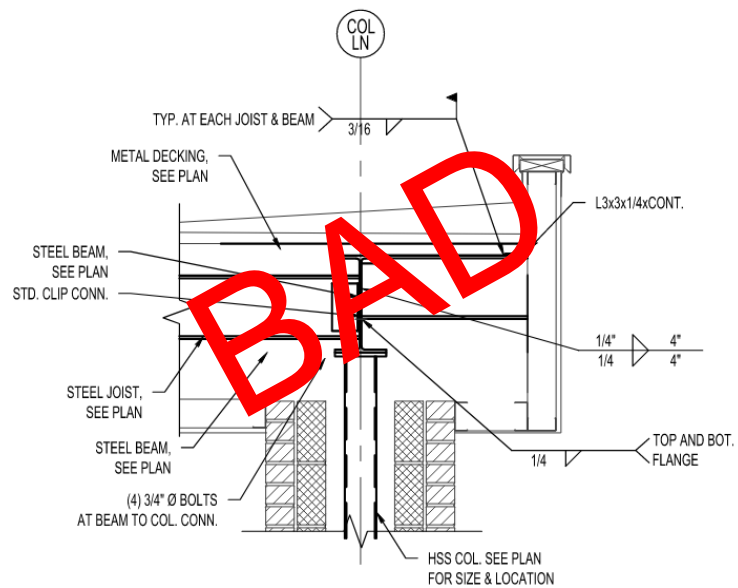


Drawing Details: Example 4



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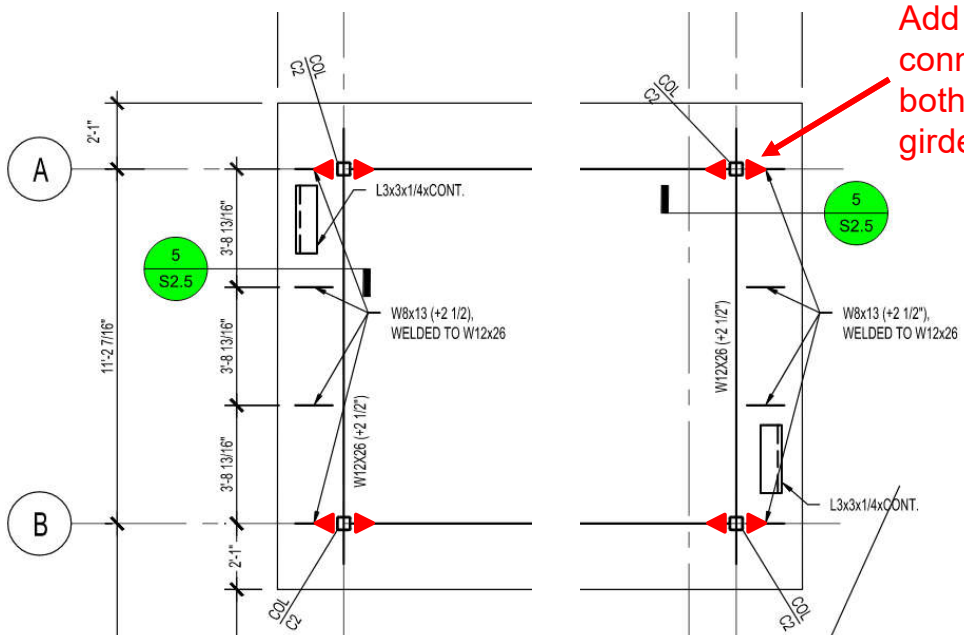
Drawing Details: Example 4



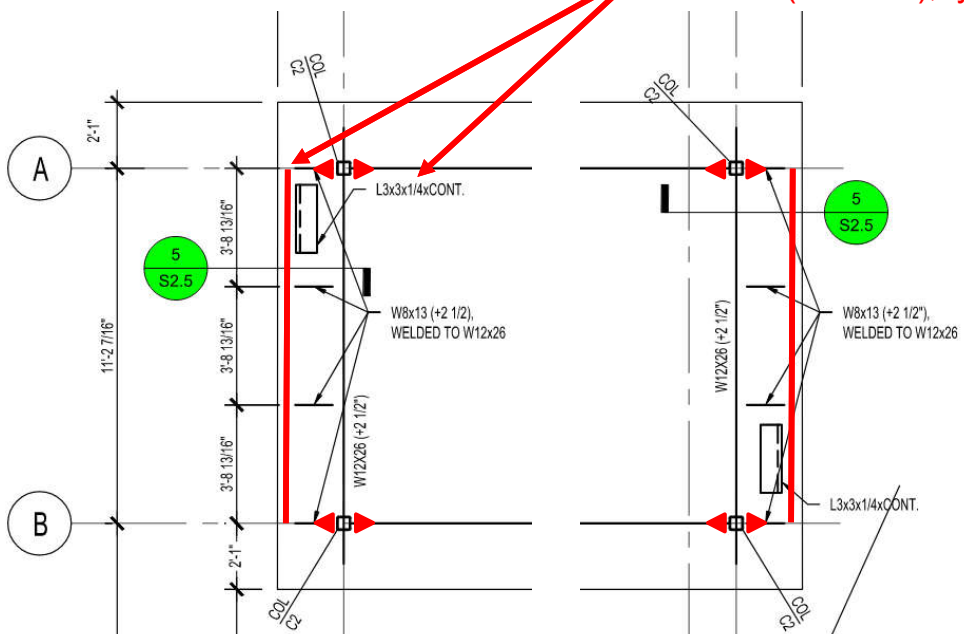
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Drawing Details: Example 4

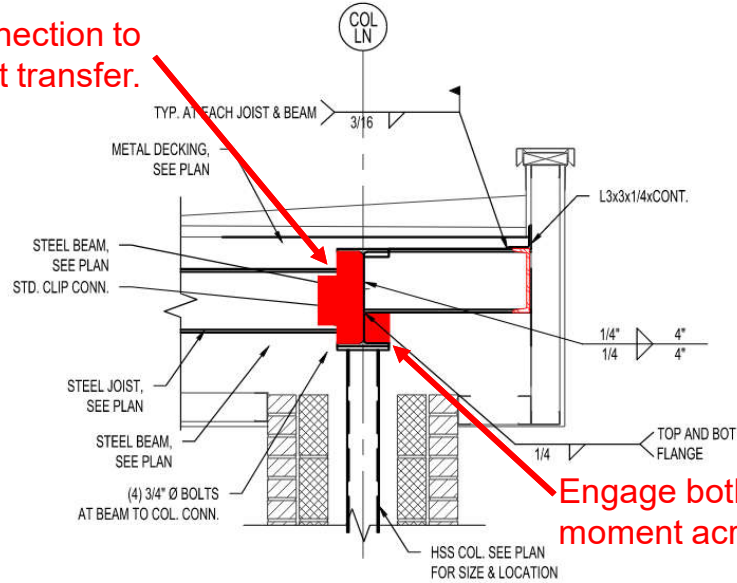


Drawing Details: Example 4



Drawing Details: Example 4

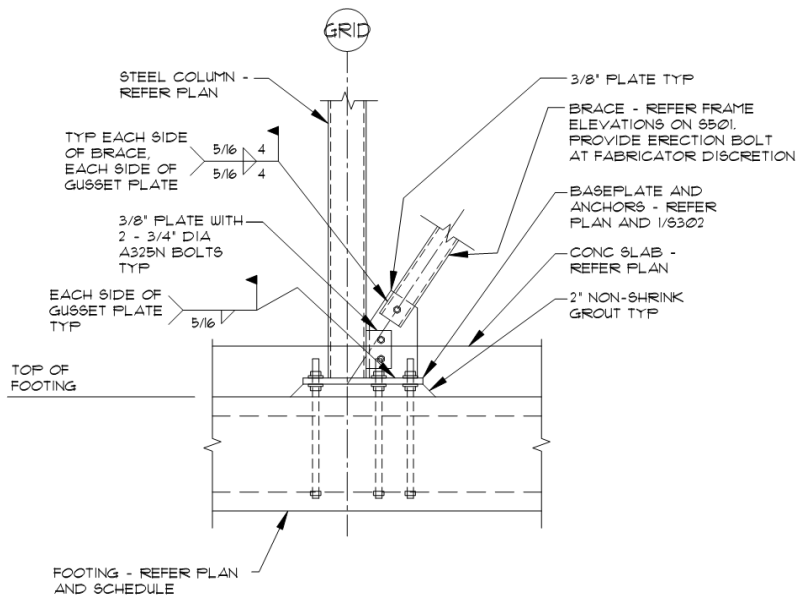
Provide connection to facilitate moment transfer.



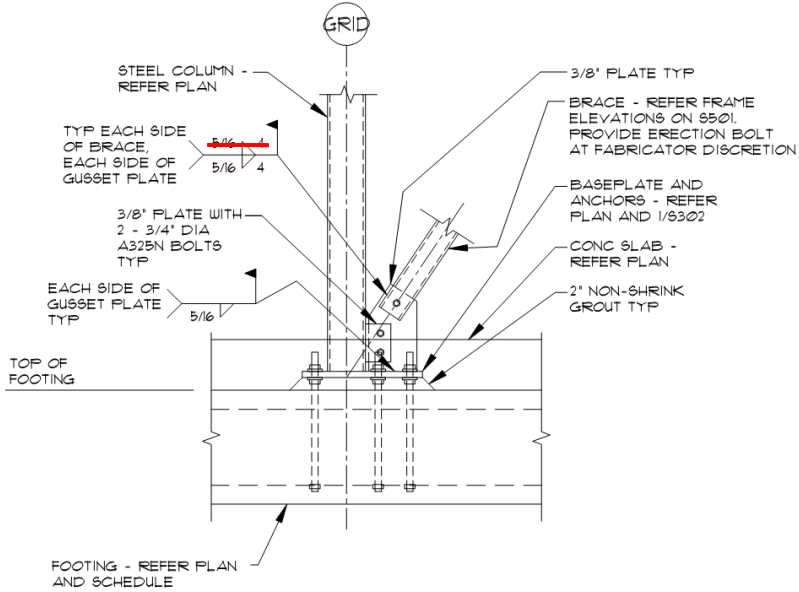
Engage both flanges to transfer moment across girder.



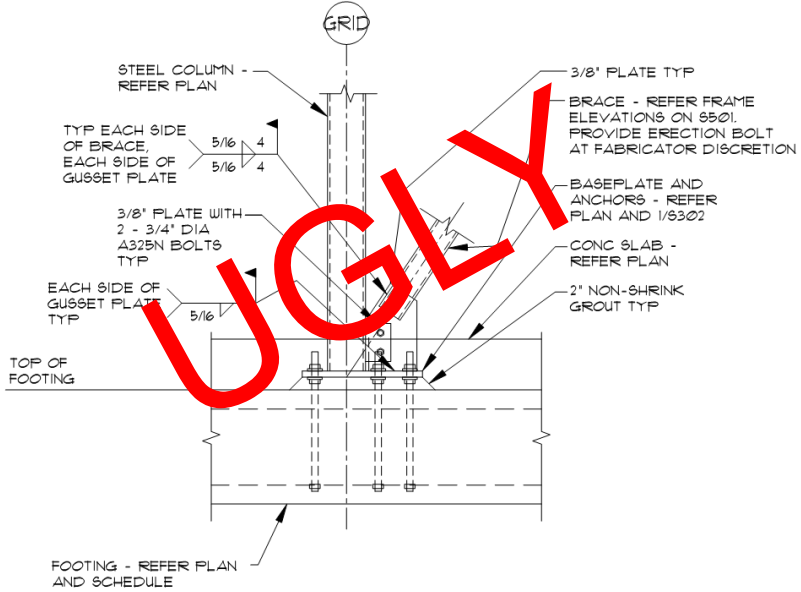
Drawing Details: Example 5



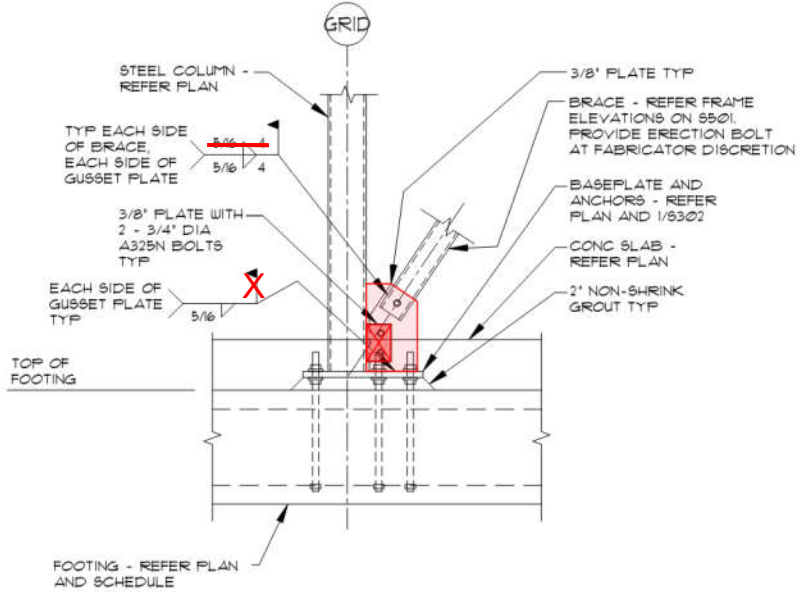
Drawing Details: Example 5



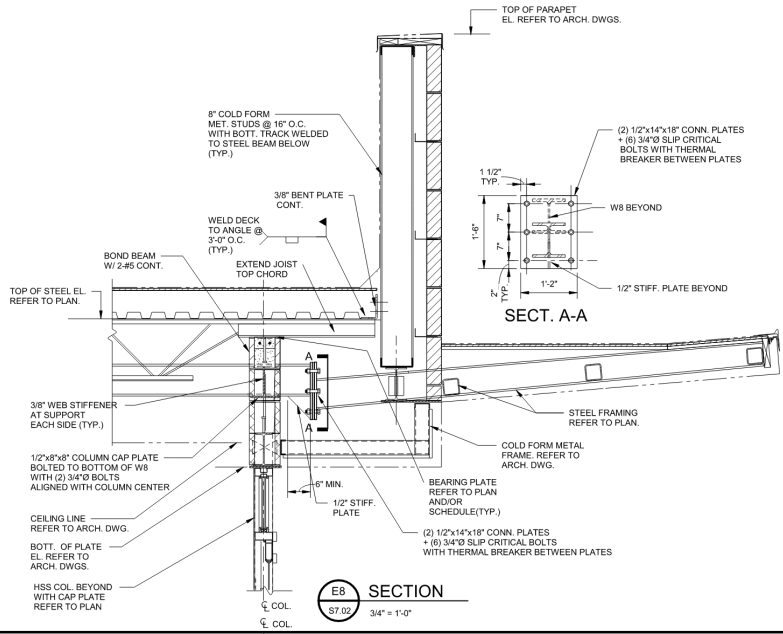
Drawing Details: Example 5



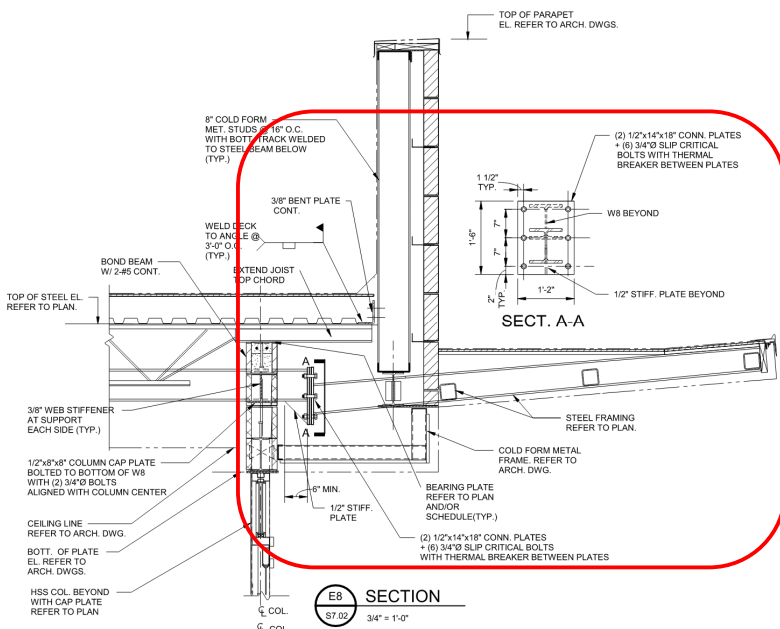
Drawing Details: Example 5



Drawing Details: Example 6



Drawing Details: Example 6

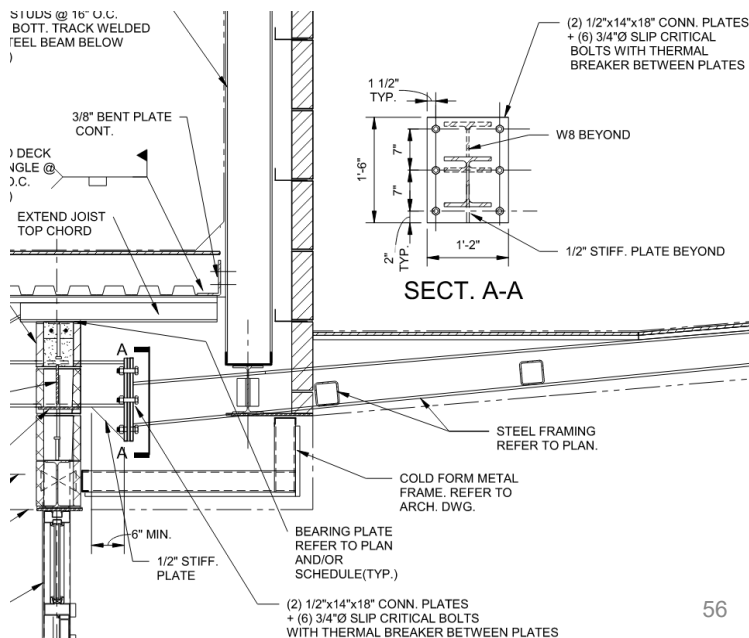


Drawing Details: Example 6

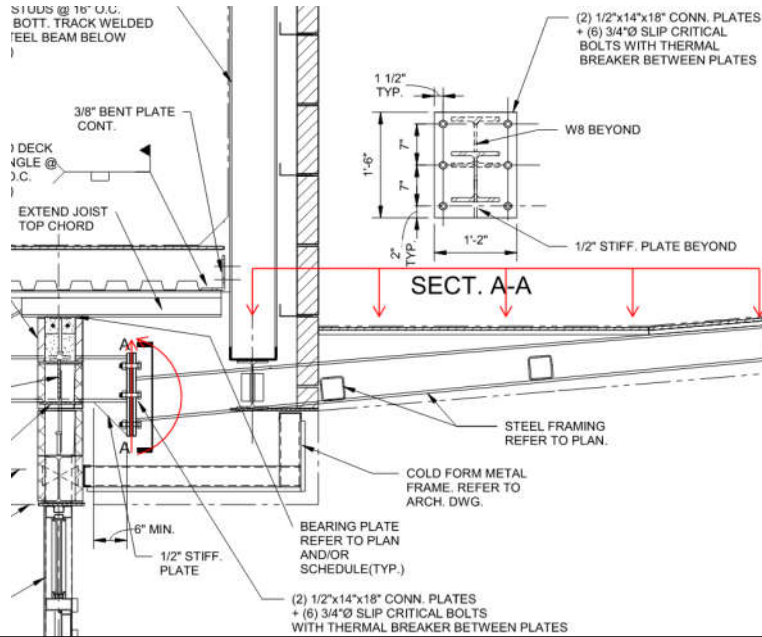
Per the *Specification for Structural Joints Using High-Strength Bolts* Section 3.1:

Unless otherwise approved by the EOR, all connected plies in a joint that are within the grip of the bolt ... shall be steel ...

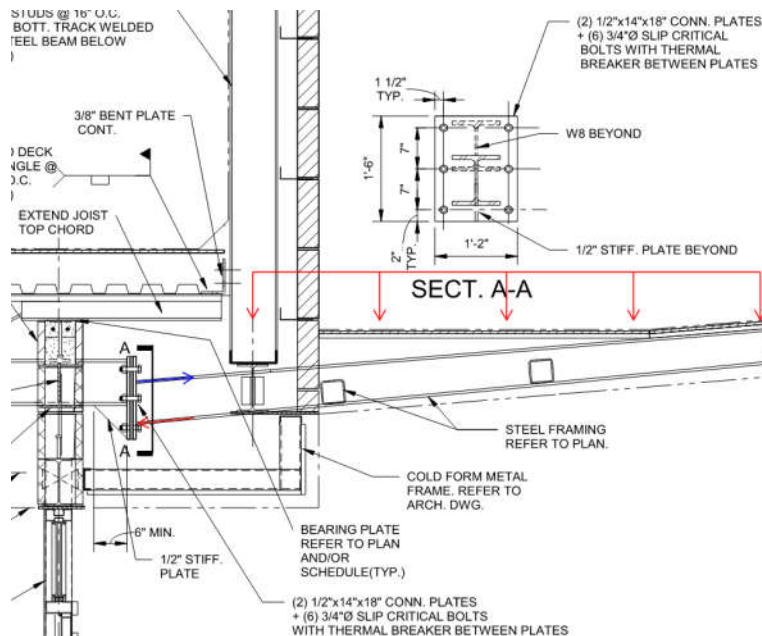
The 2020 RCSC *Specification* has additional information.



Drawing Details: Example 6



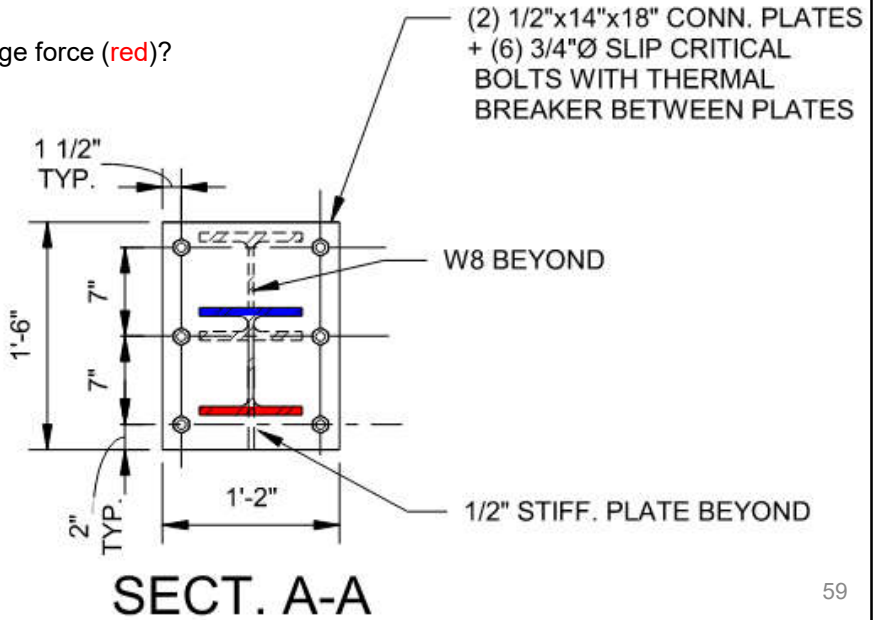
Drawing Details: Example 6



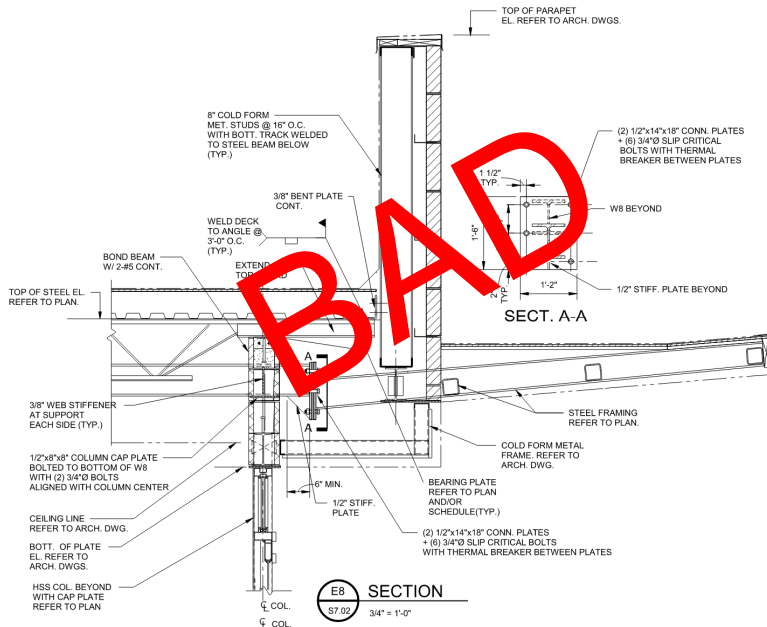
Drawing Details: Example 6

What opposes the compression flange force (red)?

What is the load path for the tension flange force (blue) to the bolts?



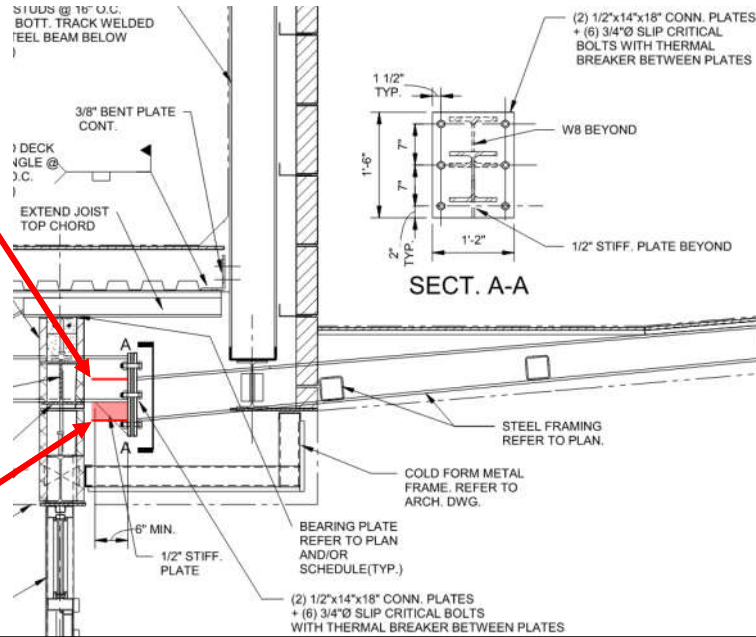
Drawing Details: Example 6



Drawing Details: Example 6

Add stiffener plate in beam web to oppose tension flange force.

Add WT to oppose compression flange force.

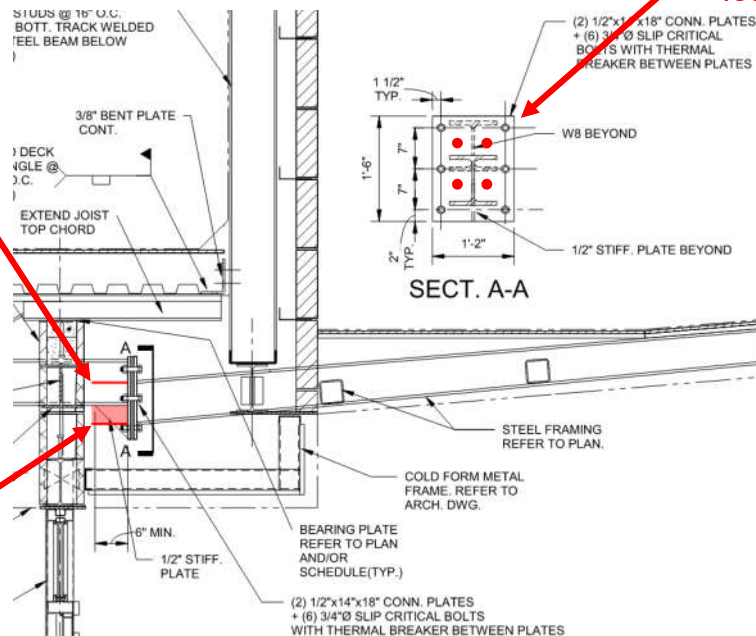


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Drawing Details: Example 6

Add stiffener plate in beam web to oppose tension flange force.

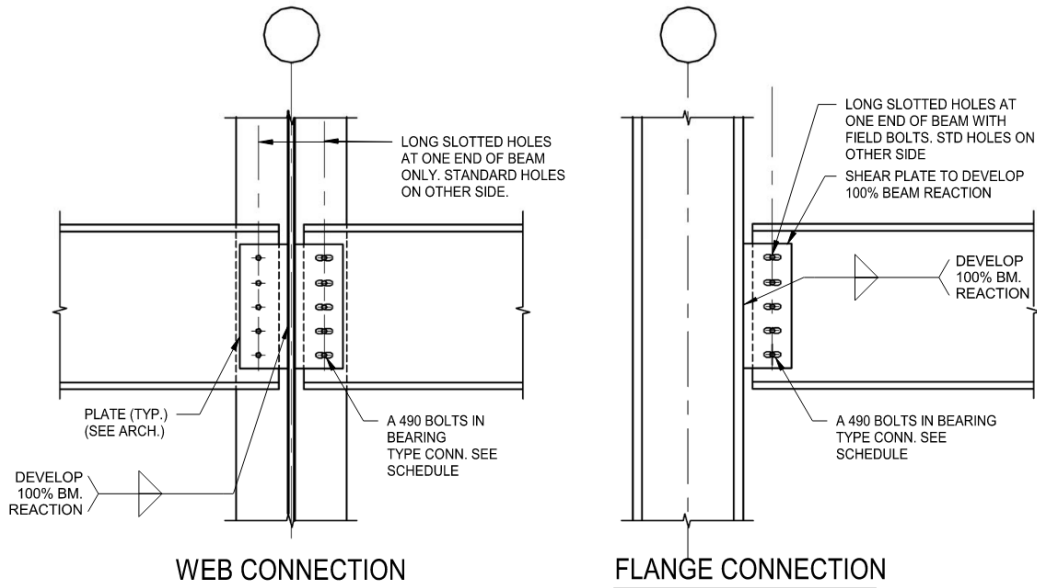
Add WT to oppose compression flange force.



Rearrange bolting pattern to facilitate load path.

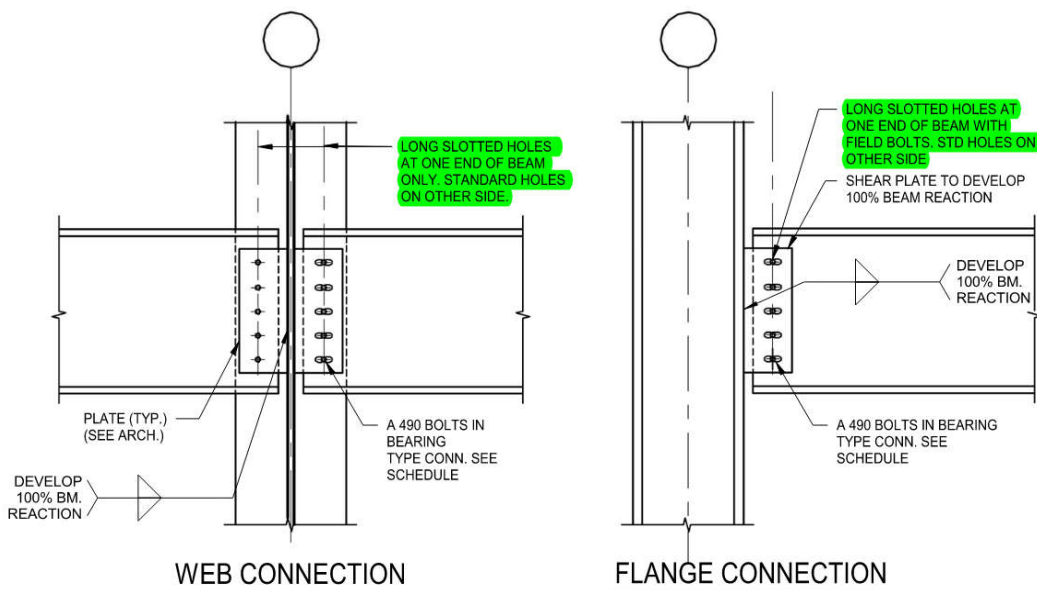
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Drawing Details: Example 7



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Drawing Details: Example 7



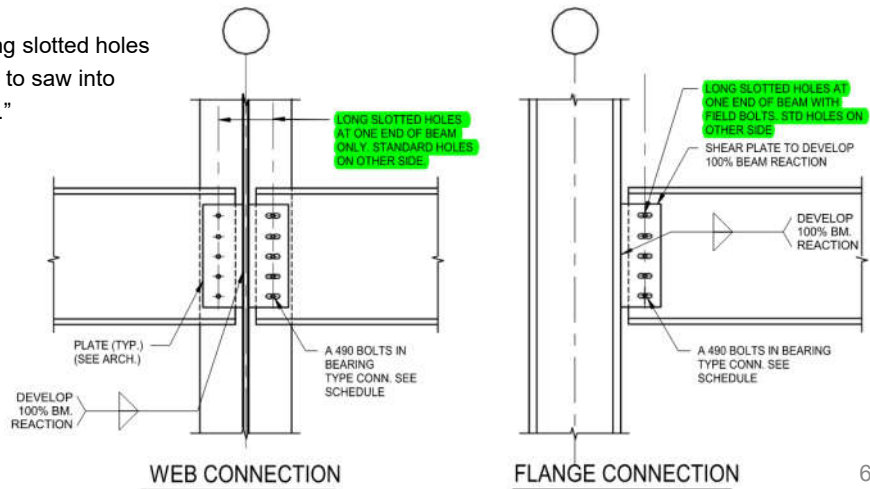
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Drawing Details: Example 7

Per Expansion Joint Considerations for Buildings
 from the May 2011 edition of Modern Steel Construction:

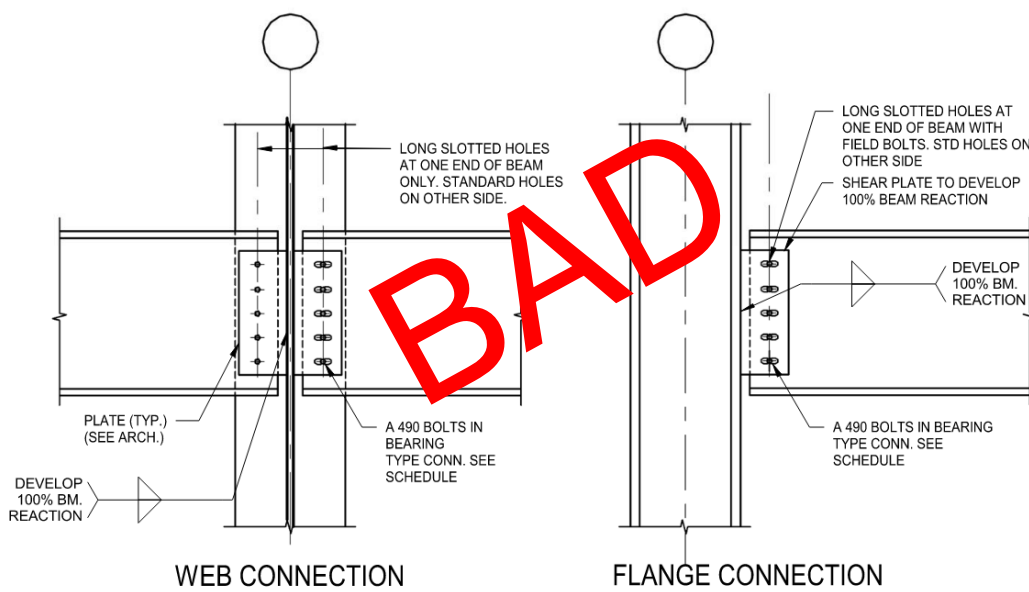
"The use of shear connections with long slotted holes **is not recommended**. The bolts tend to saw into the sides of the holes, locking the joint."



65



Drawing Details: Example 7



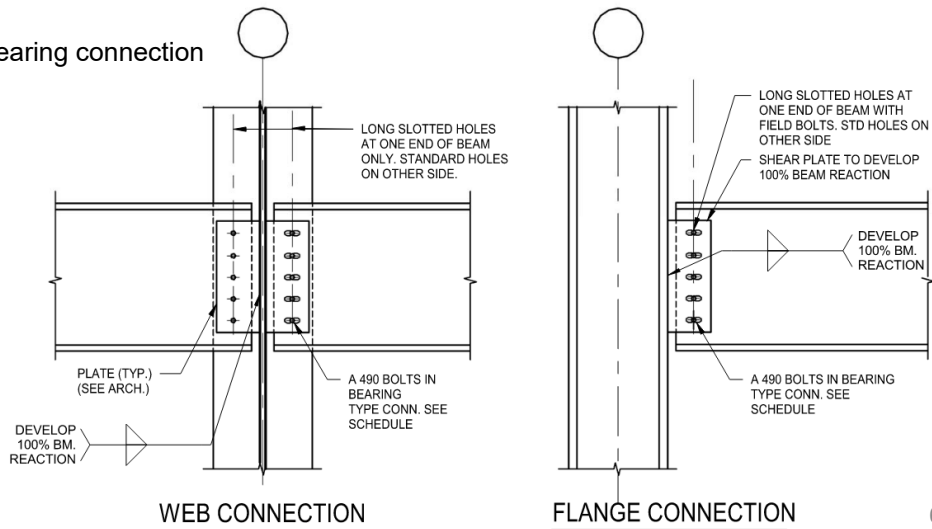
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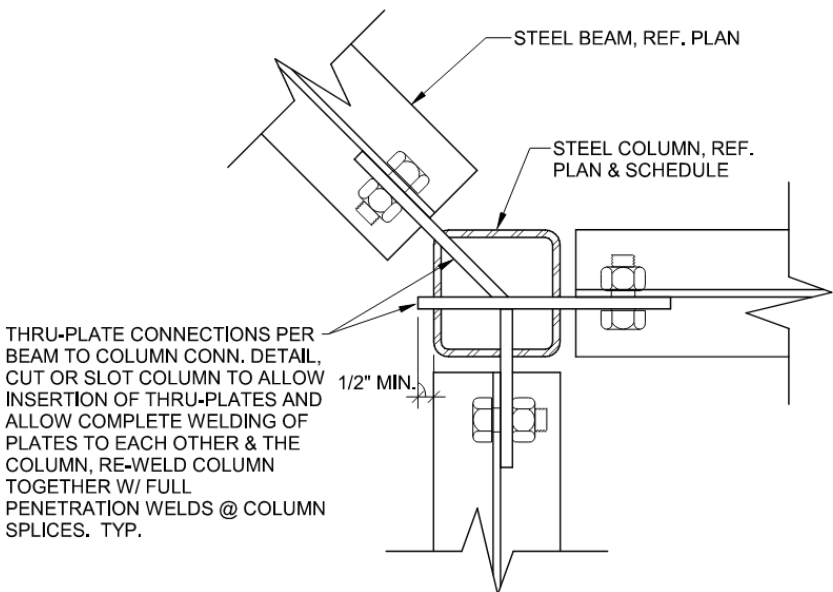
Drawing Details: Example 7

Instead, use:

- Double line of columns
- Slip surface joint at a bearing connection



Drawing Details: Example 8



THRU-PLATE CONNECTIONS PER BEAM TO COLUMN CONN. DETAIL. CUT OR SLOT COLUMN TO ALLOW INSERTION OF THRU-PLATES AND ALLOW COMPLETE WELDING OF PLATES TO EACH OTHER & THE COLUMN, RE-WELD COLUMN TOGETHER W/ FULL PENETRATION WELDS @ COLUMN SPLICES. TYP.



Drawing Details: Example 8

Per Part 10 of the Steel Construction Manual:

As long as the HSS wall is not classified as a slender element, the local distortion caused by the single-plate connection will be insignificant in reducing the column strength of the HSS.

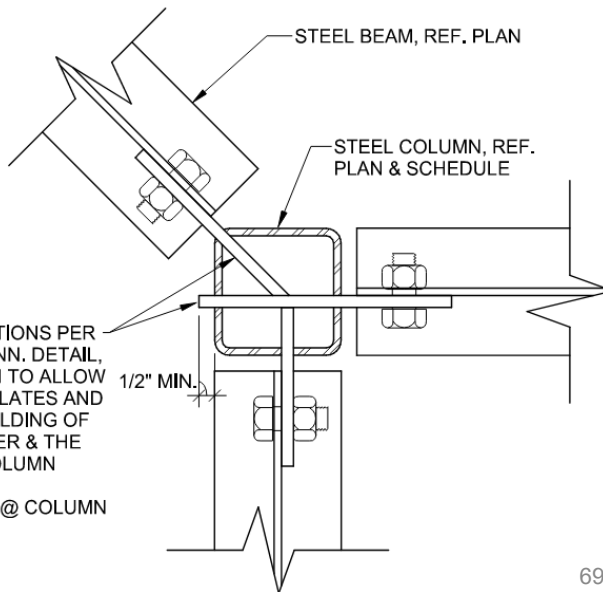
Therefore, single-plate connections may be used...

Use Equations 10-7(a) or (b):

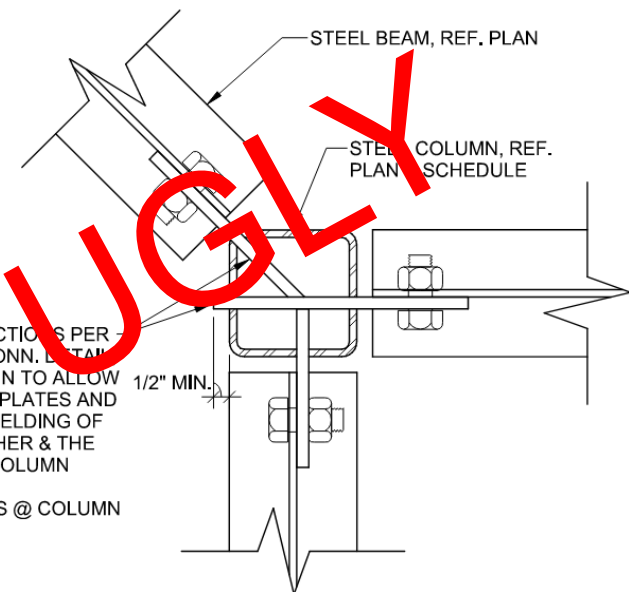
$$R_{ve} \leq \phi F_u t_p^2 / 5$$

$$R_{ae} \leq F_u t_p^2 / 5\Omega$$

THRU-PLATE CONNECTIONS PER BEAM TO COLUMN CONN. DETAIL, CUT OR SLOT COLUMN TO ALLOW INSERTION OF THRU-PLATES AND ALLOW COMPLETE WELDING OF PLATES TO EACH OTHER & THE COLUMN, RE-WELD COLUMN TOGETHER W/ FULL PENETRATION WELDS @ COLUMN SPLICES. TYP.



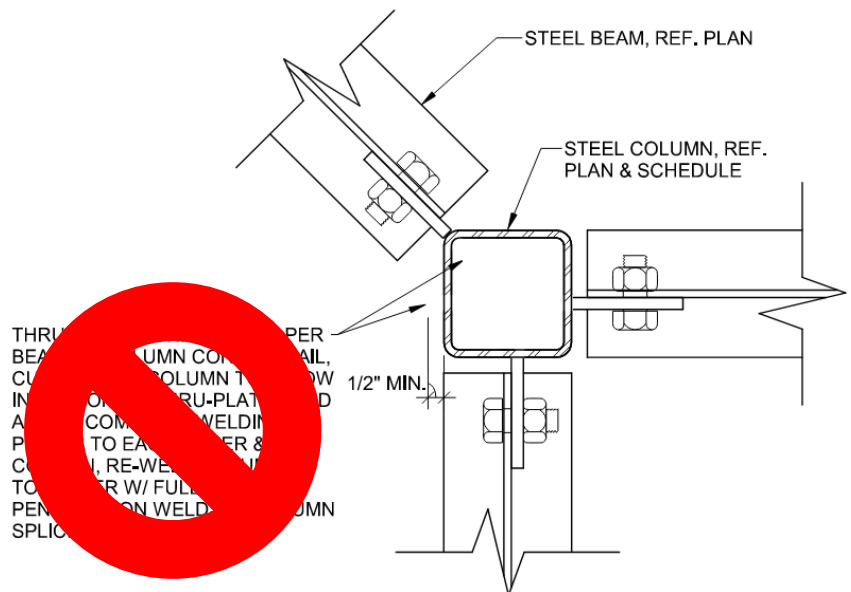
Drawing Details: Example 8



THRU-PLATE CONNECTIONS PER BEAM TO COLUMN CONN. DETAIL, CUT OR SLOT COLUMN TO ALLOW INSERTION OF THRU-PLATES AND ALLOW COMPLETE WELDING OF PLATES TO EACH OTHER & THE COLUMN, RE-WELD COLUMN TOGETHER W/ FULL PENETRATION WELDS @ COLUMN SPLICES. TYP.



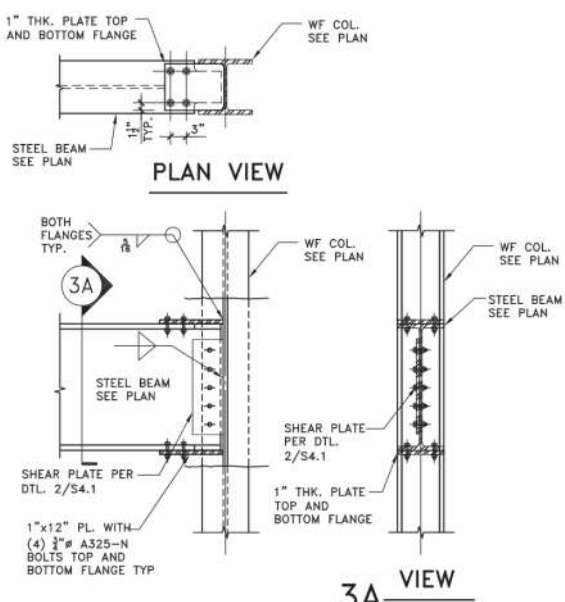
Drawing Details: Example 8



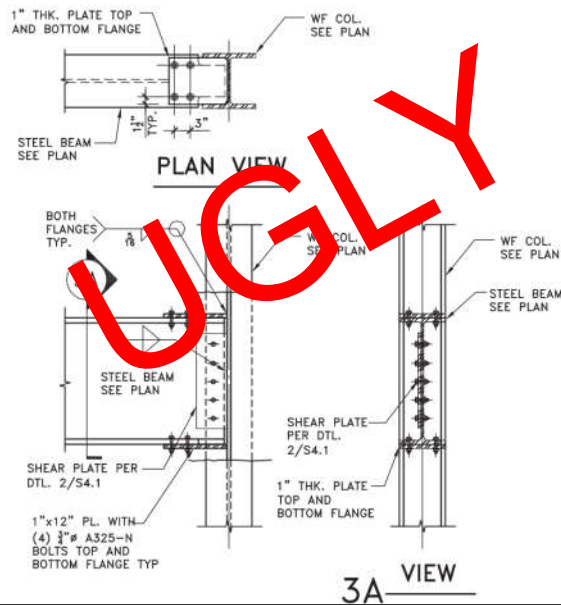
THRU COLUMN CONNECTION, PER AISC 360-10, SECTION J10.2.1.1. THE CONNECTION SHALL BE DESIGNED AS A MOMENT RESISTING CONNECTION. THE CONNECTION SHALL BE DESIGNED TO RESIST THE FULL DESIGN MOMENT AND SHEAR. THE CONNECTION SHALL BE DESIGNED TO RESIST THE FULL DESIGN SHEAR. THE CONNECTION SHALL BE DESIGNED TO RESIST THE FULL DESIGN MOMENT AND SHEAR. THE CONNECTION SHALL BE DESIGNED TO RESIST THE FULL DESIGN MOMENT AND SHEAR.



Drawing Details: Example 9

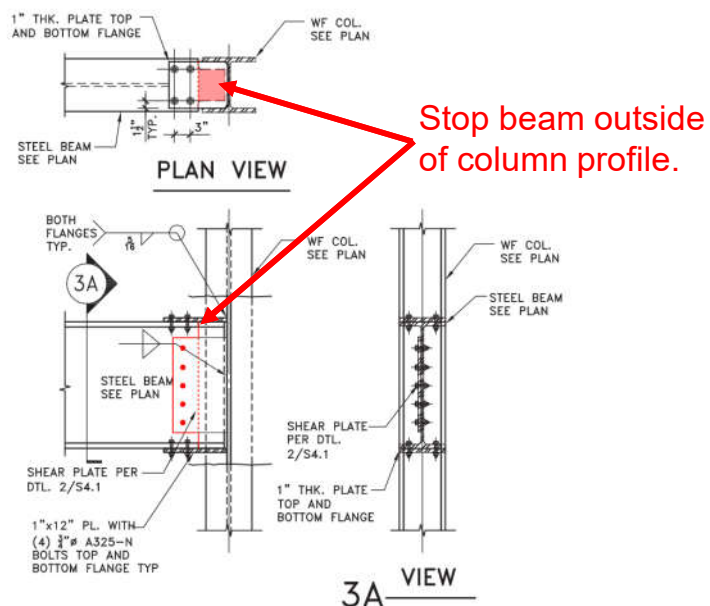


Drawing Details: Example 9



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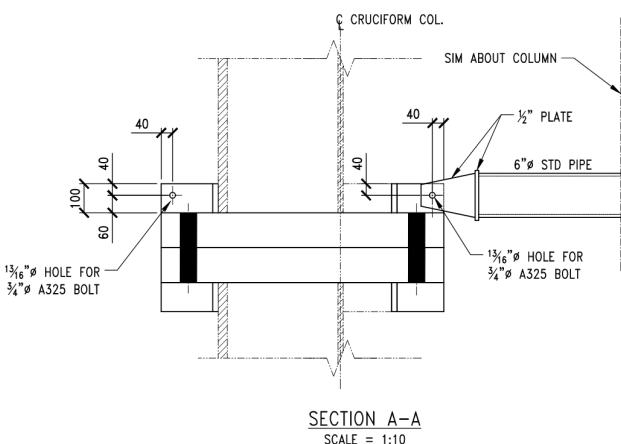
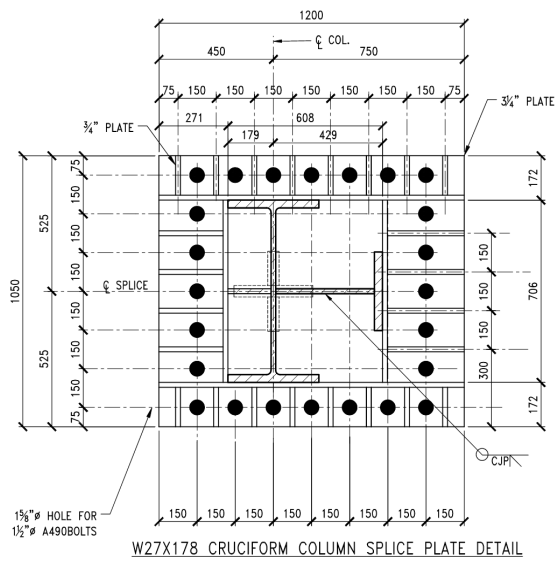
Drawing Details: Example 9



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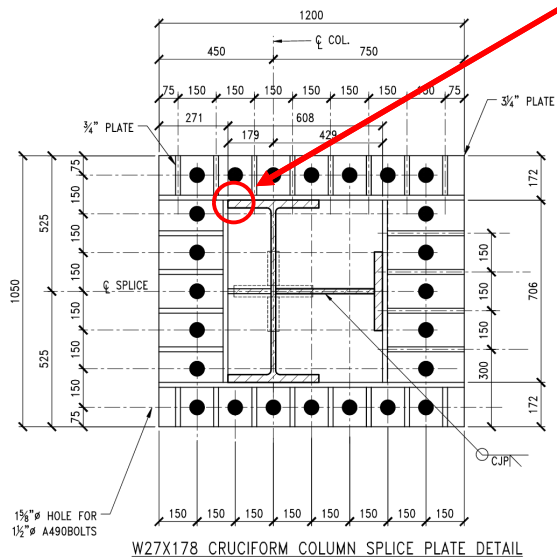


Drawing Details: Example 10

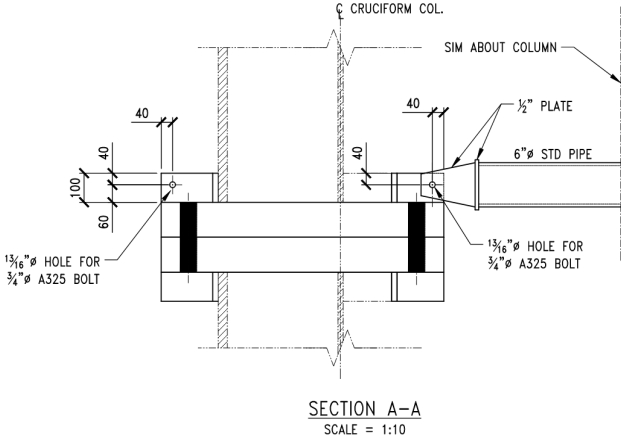


W27X178 CRUCIFORM COLUMN SPLICE PLATE DETAIL

Drawing Details: Example 10



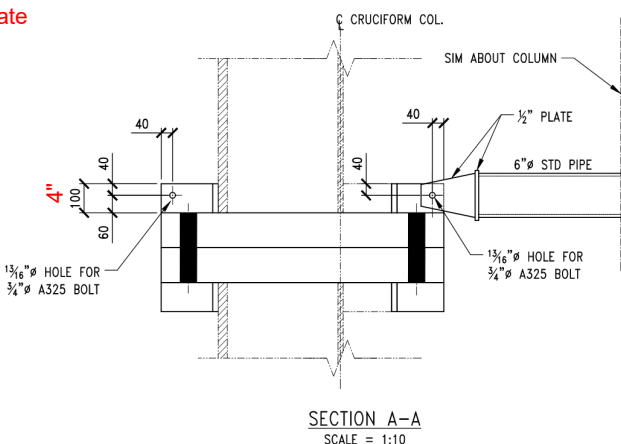
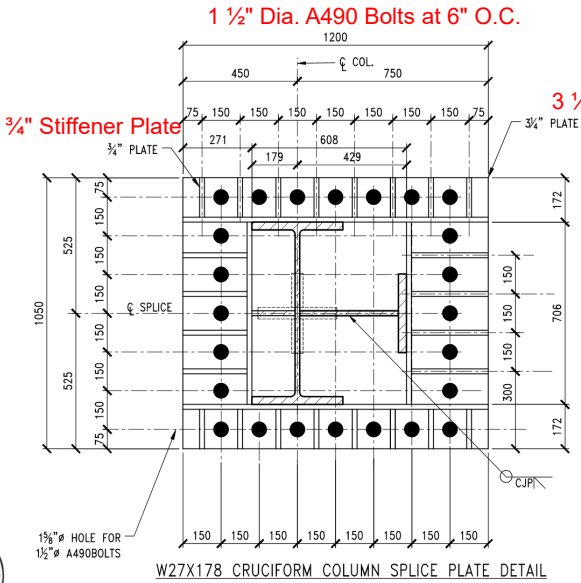
How would this be welded?



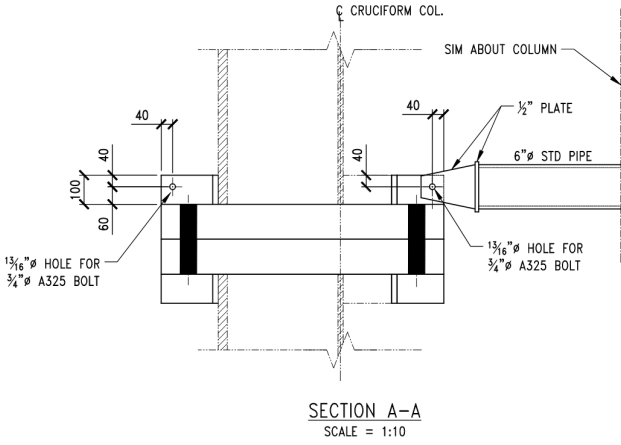
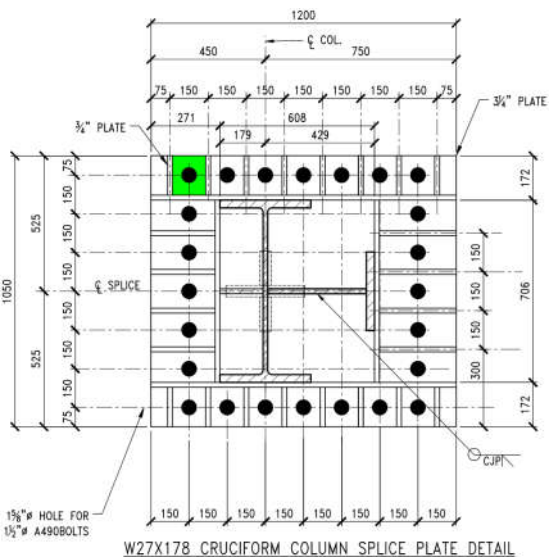
W27X178 CRUCIFORM COLUMN SPLICE PLATE DETAIL



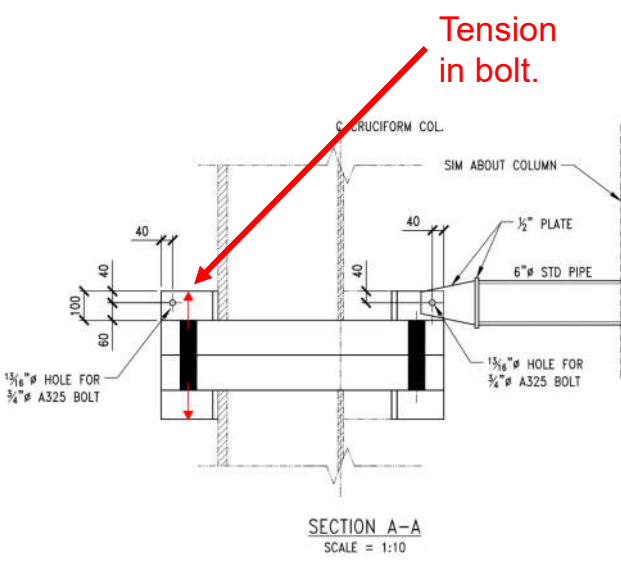
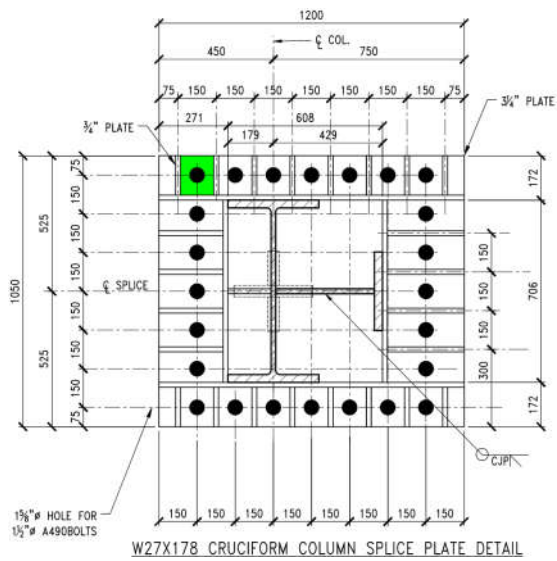
Drawing Details: Example 10



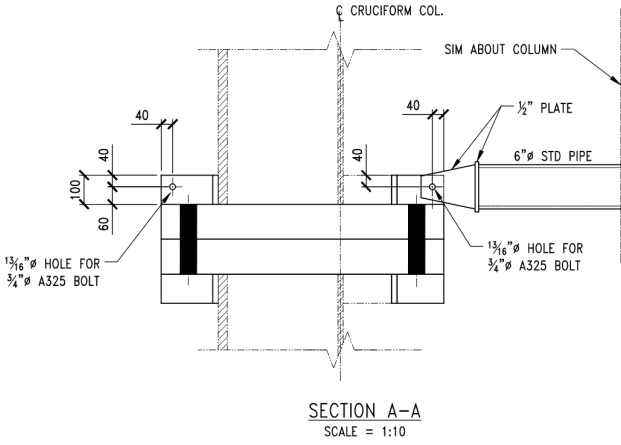
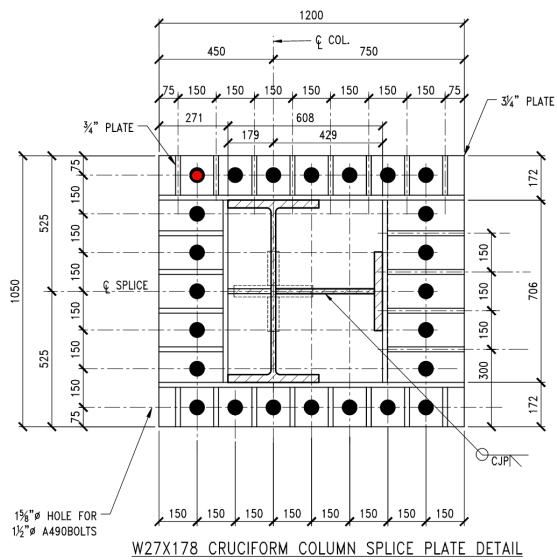
Drawing Details: Example 10



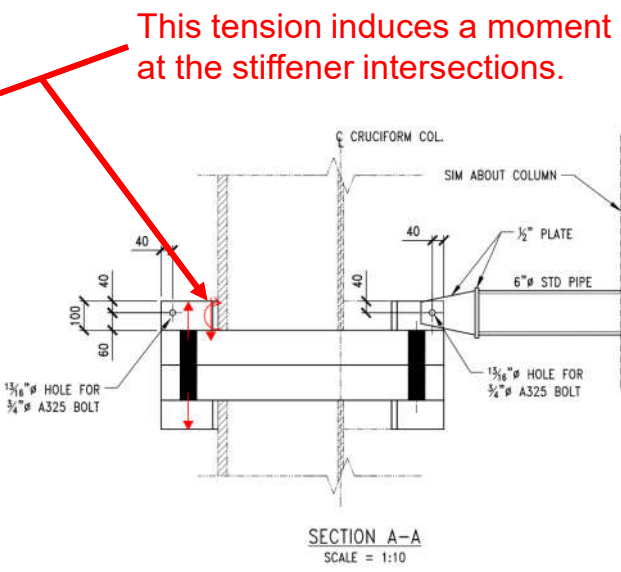
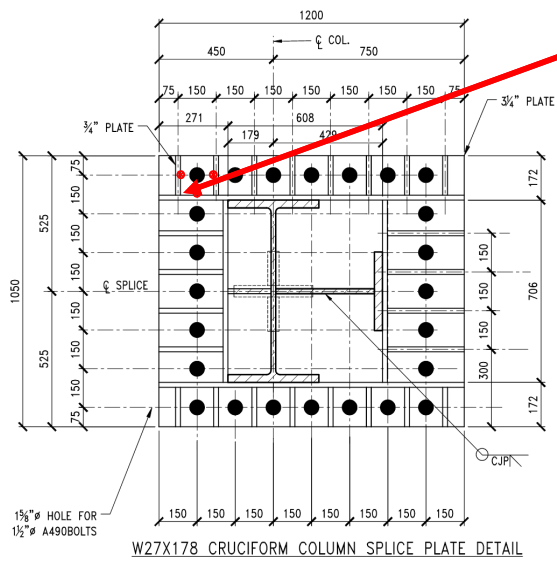
Drawing Details: Example 10



Drawing Details: Example 10



Drawing Details: Example 10

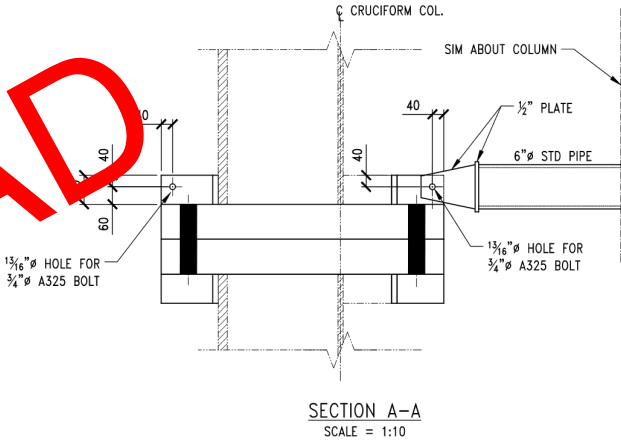
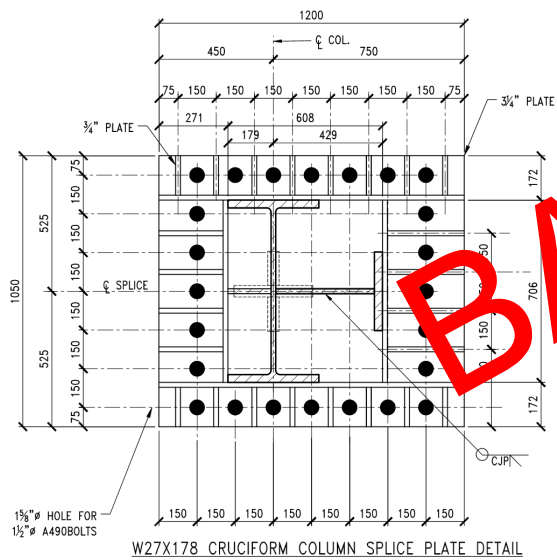


This tension induces a moment at the stiffener intersections.



W27X178 CRUCIFORM COLUMN SPLICE PLATE DETAIL

Drawing Details: Example 10



BAD



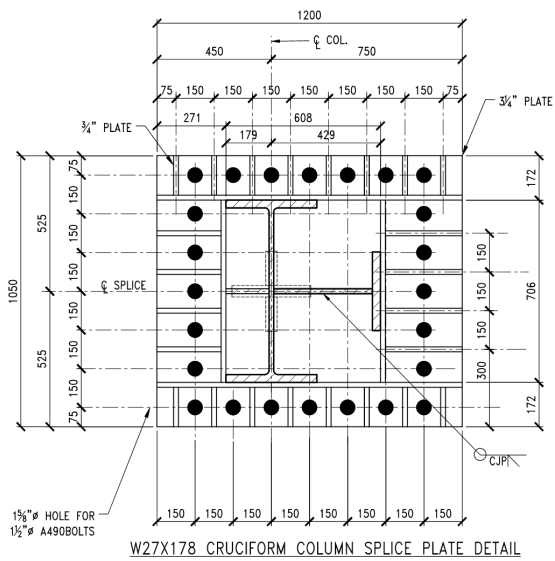
W27X178 CRUCIFORM COLUMN SPLICE PLATE DETAIL



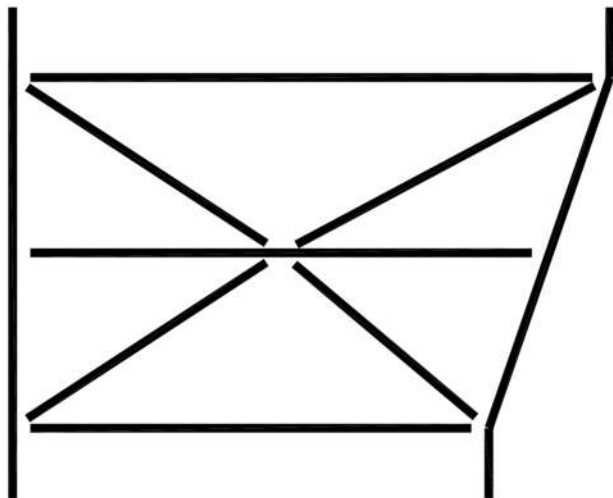
Drawing Details: Example 10

A good solution????

...would have to have a better understanding of the magnitude of loads.



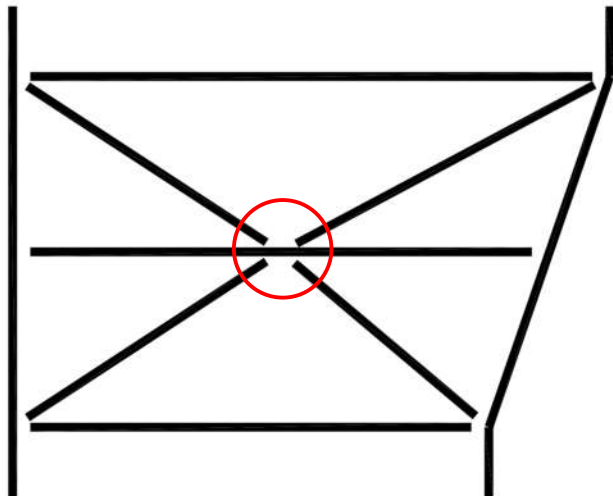
Drawing Details: Example 11



Truss Elevation



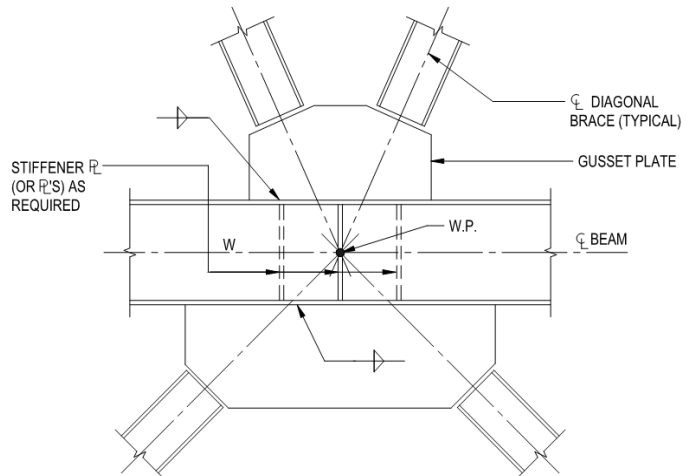
Drawing Details: Example 11



Truss Elevation



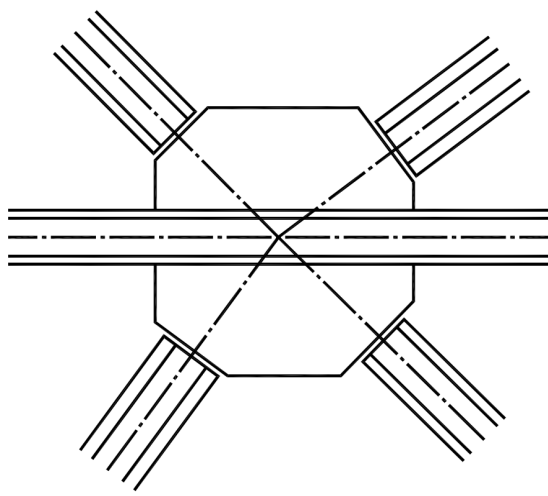
Drawing Details: Example 11



Panel Point Connection Concept from Design Drawings



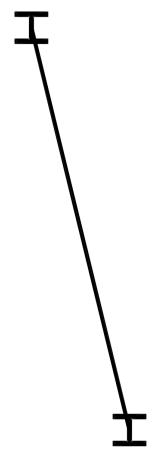
Drawing Details: Example 11



Initial Panel Point Connection Concept



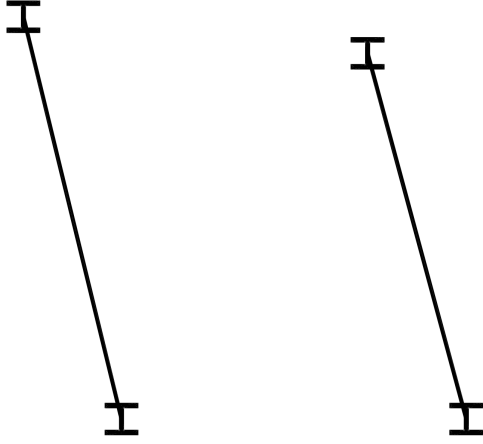
Drawing Details: Example 11



Top Chord



Drawing Details: Example 11

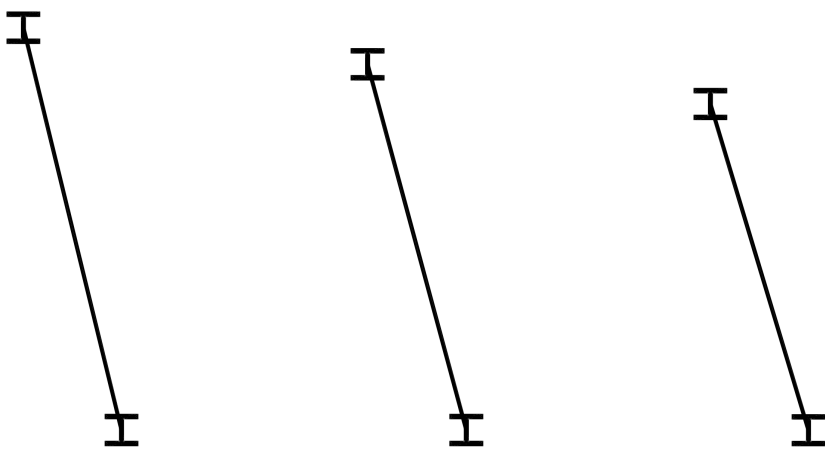


Top Chord

Mid Chord



Drawing Details: Example 11



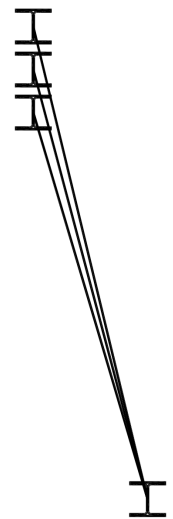
Top Chord

Mid Chord

Bottom Chord



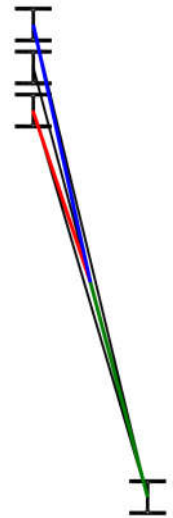
Drawing Details: Example 11



Superimposed Chords



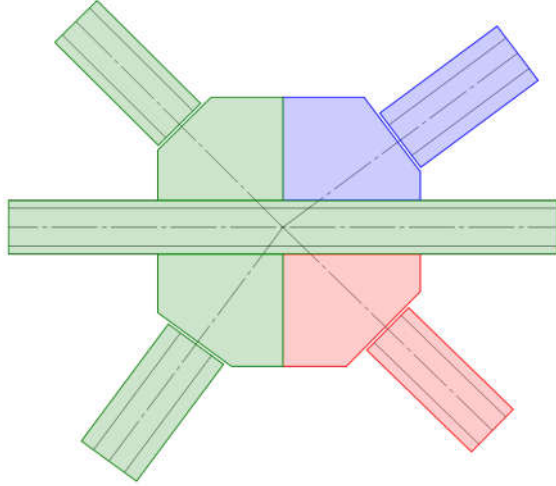
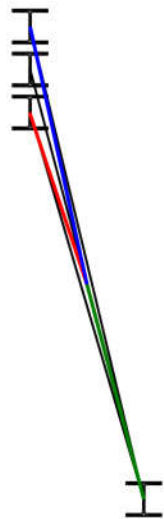
Drawing Details: Example 11



Superimposed Chords



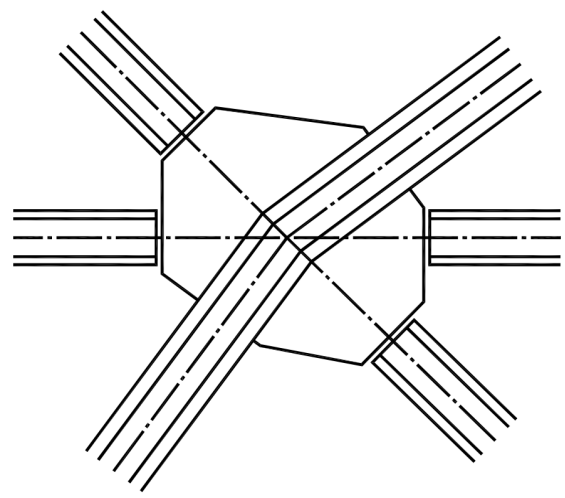
Drawing Details: Example 11



Panel Point Connection Concept



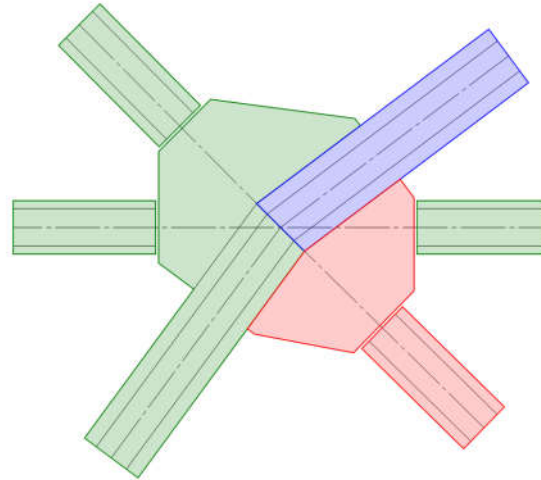
Drawing Details: Example 11



Panel Point Connection Concept



Drawing Details: Example 11

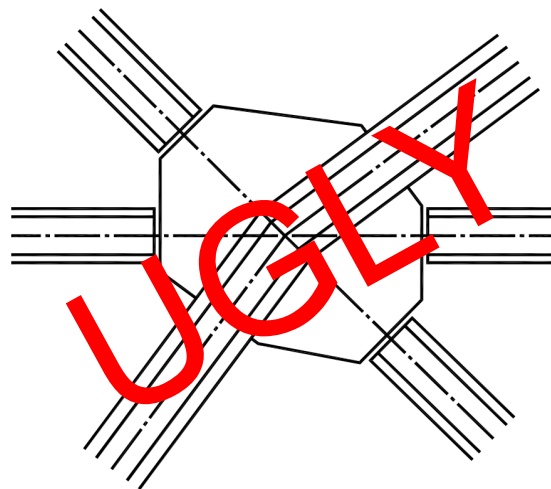


Panel Point Connection Concept



95

Drawing Details: Example 11



Panel Point Connection Concept



96



Drawing Details: Example 12



97

Drawing Details: Example 12



98



Drawing Details: Example 13



Drawing Details: Example 13



Drawing Details: Example 13



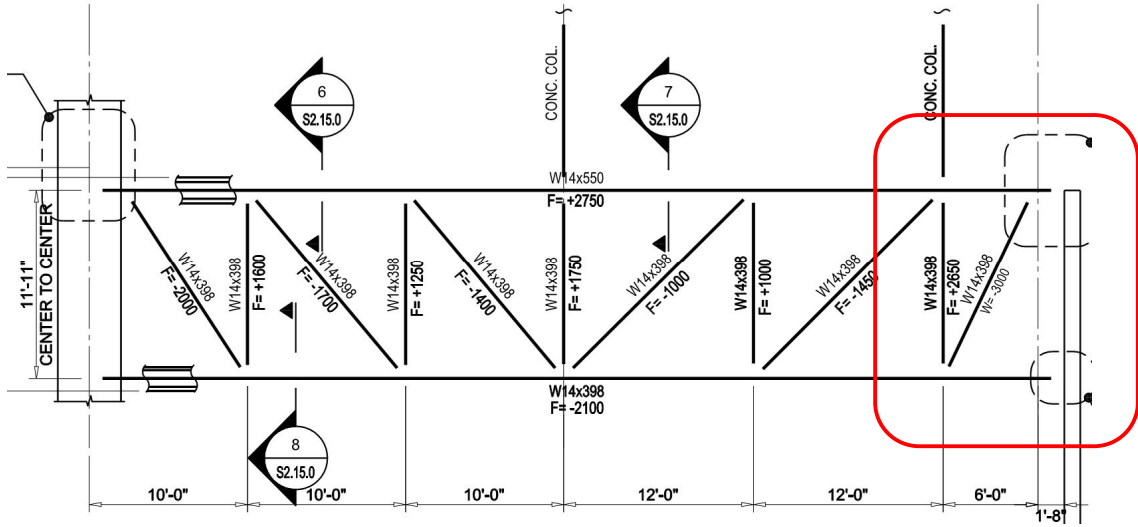
101

Drawing Details: Example 13

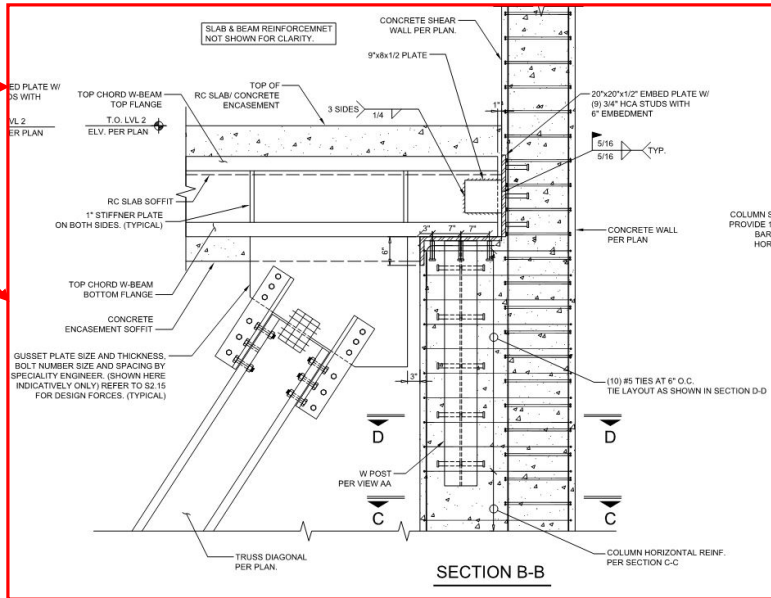
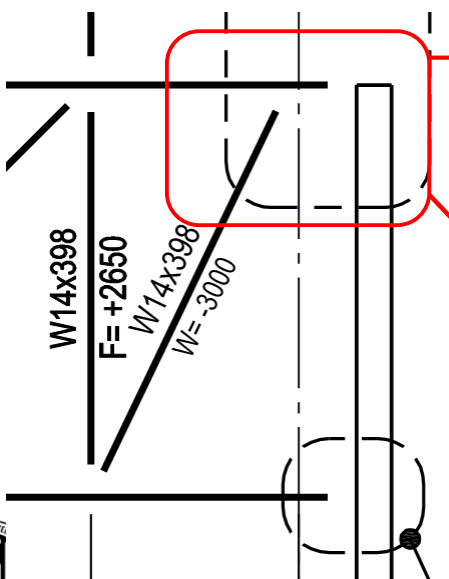


102

Drawing Details: Example 14



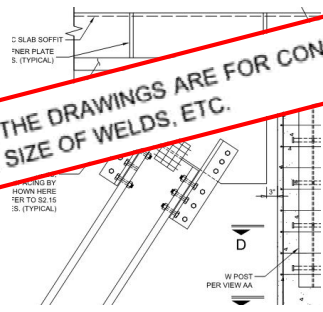
Drawing Details: Example 14



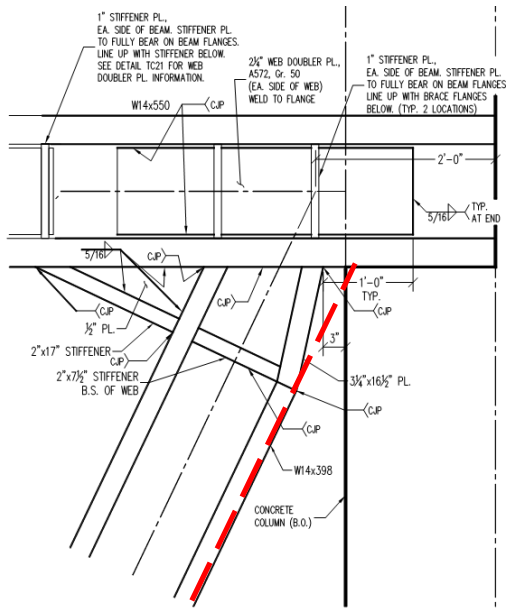
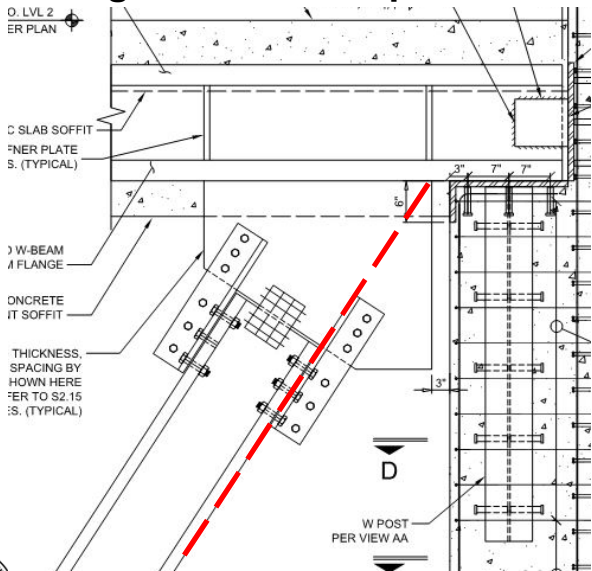
Drawing Details: Example 14

- Quick check of detail:
- $P_a = 3,000$ kips
- Try 8x8x1 angle
- $A = 15.1 \text{ in}^2 / \text{angle}$
- Try 4
- $4 * 15.1 \text{ in}^2 * 50 \text{ ksi} / 1.67$
- $P/\Omega = 1,808$ kips !!!!
- Conceptual Detail Does Not Work

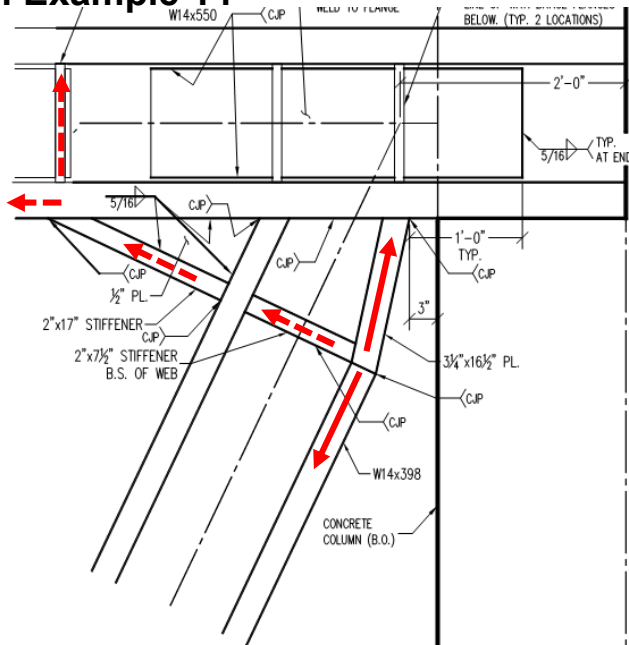
14. UNLESS SPECIFICALLY NOTED, STEEL DETAILS SHOWN ON THE DRAWINGS ARE FOR CONCEPT ONLY AND DO NOT INDICATE REQUIRED NUMBER OF BOLTS, SIZE OF WELDS, ETC.



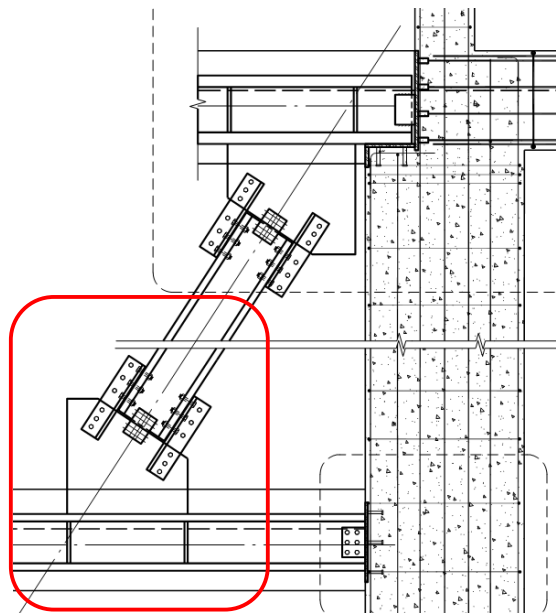
Drawing Details: Example 14



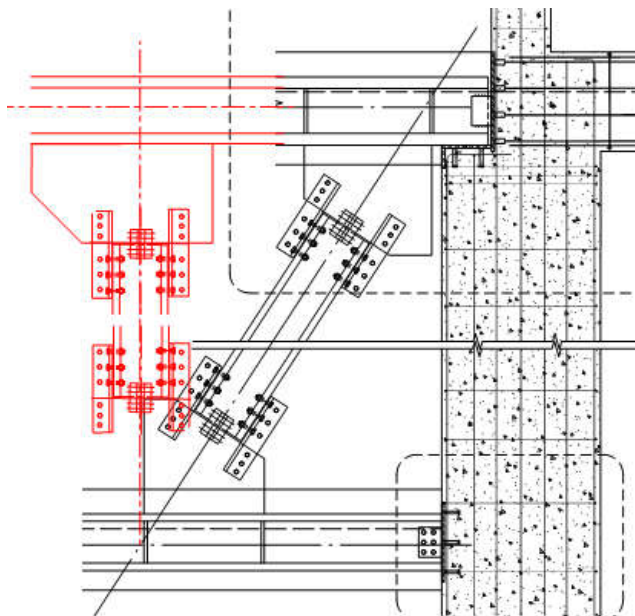
Drawing Details: Example 14



Drawing Details: Example 14

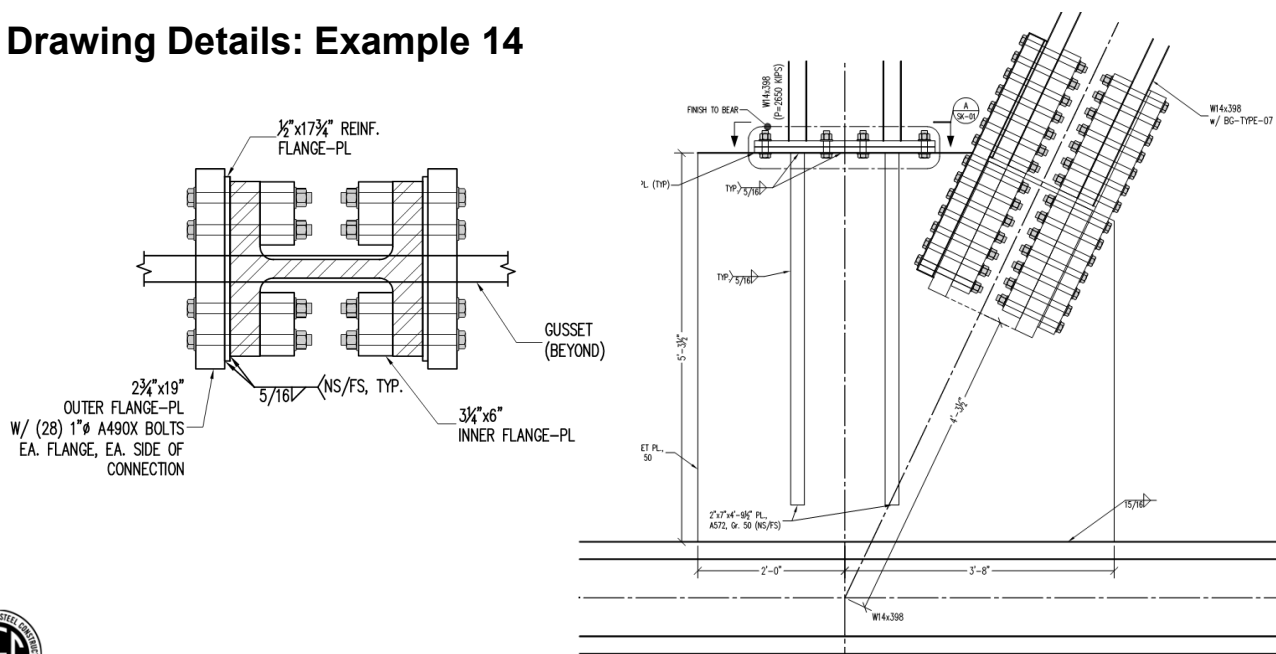


Drawing Details: Example 14



109

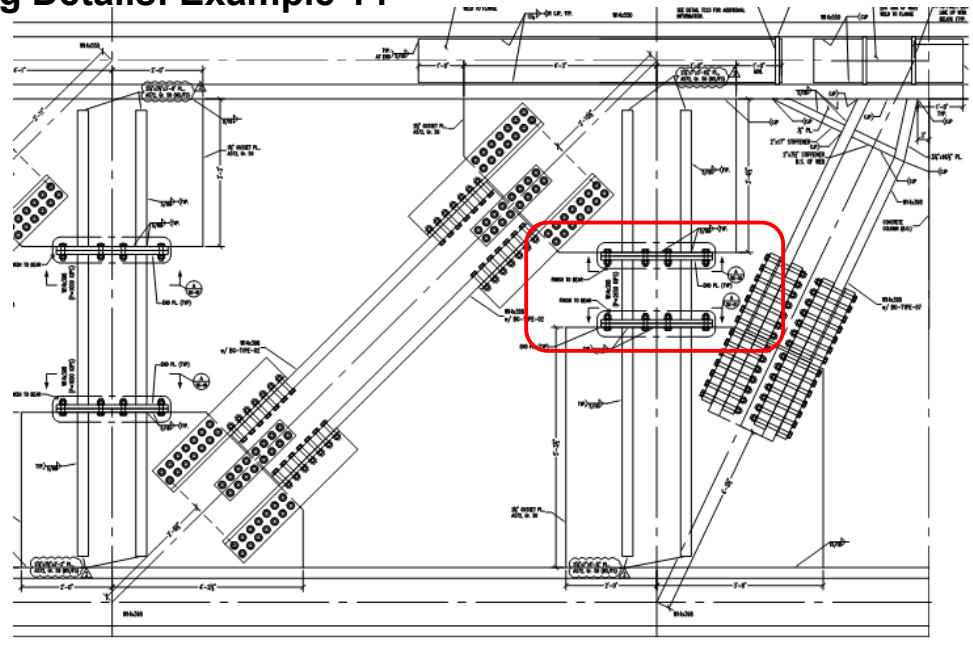
Drawing Details: Example 14



110

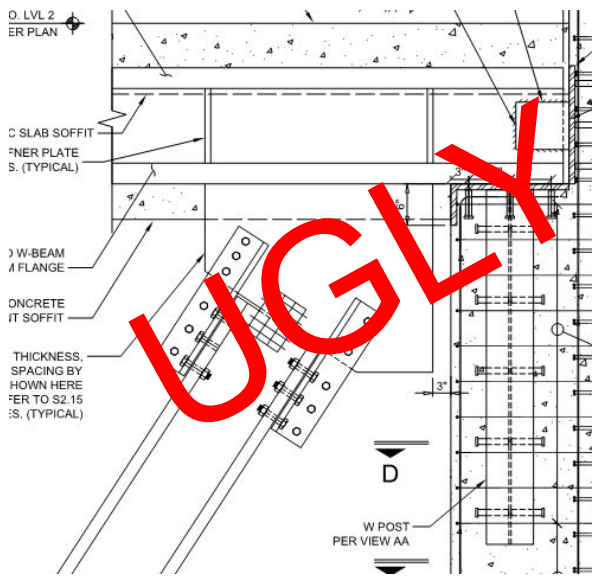


Drawing Details: Example 14



111

Drawing Details: Example 14



112



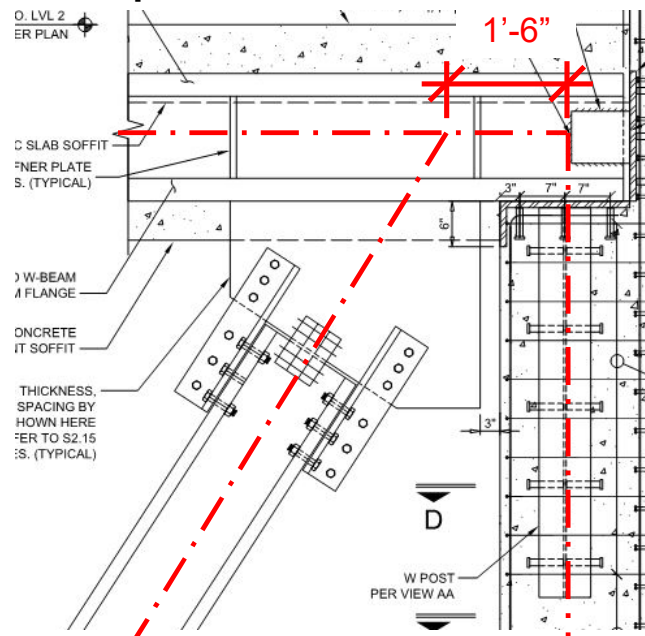
Drawing Details: Example 14

WAIT... There's more



113

Drawing Details: Example 14

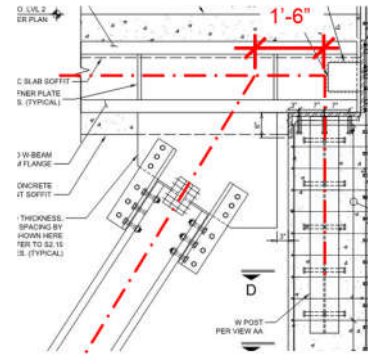


114



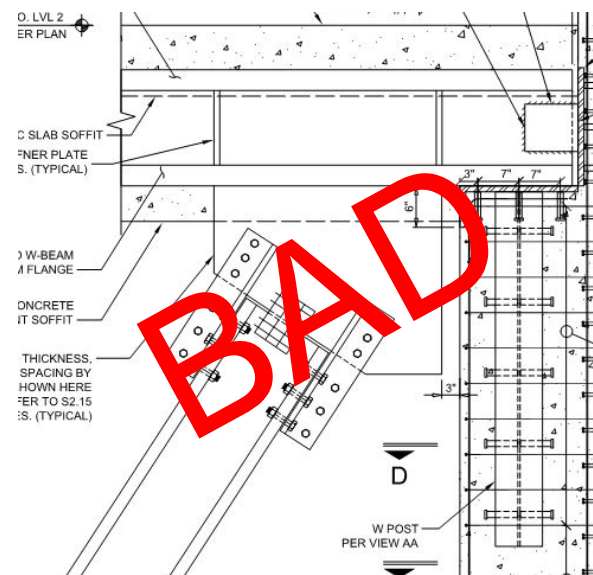
Drawing Details: Example 14

- Yet another quick check of detail:
- $P_a = 3,000$ kips (Diagonal)
- Vertical Component
- $P_{a_{vert}} = 3,000 \text{ kips} * \sin(65)$
- $P_{a_{vert}} = 2,718$ kips
- $M_a = 2,718 \text{ kips} * 1.5 \text{ ft} = 4,077 \text{ kip-ft}$
- Chord Member is W14x550
- $V/\Omega = 962$ kips, $M_p/\Omega = 2,940 \text{ kip-ft}$
- **WARNING... WARNING... WARNING**



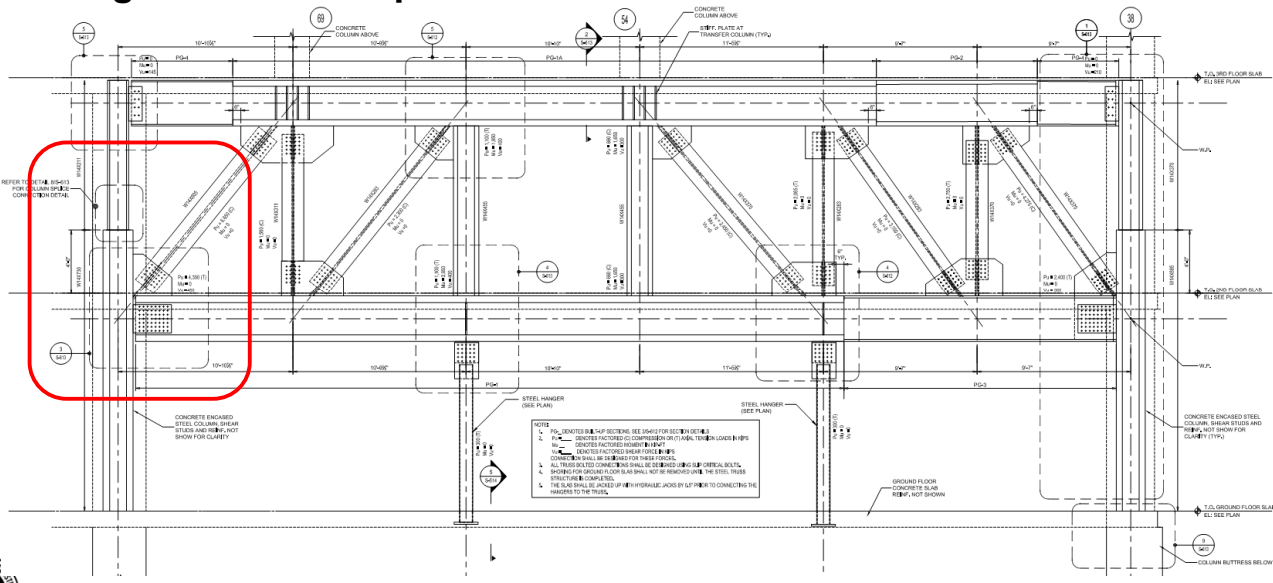
115

Drawing Details: Example 14



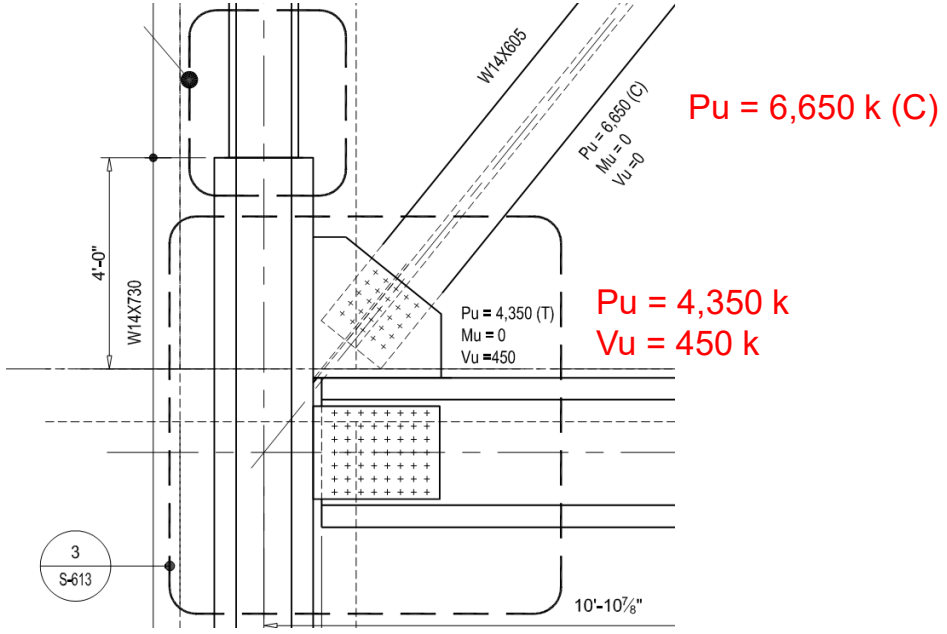
116

Drawing Details: Example 15



117

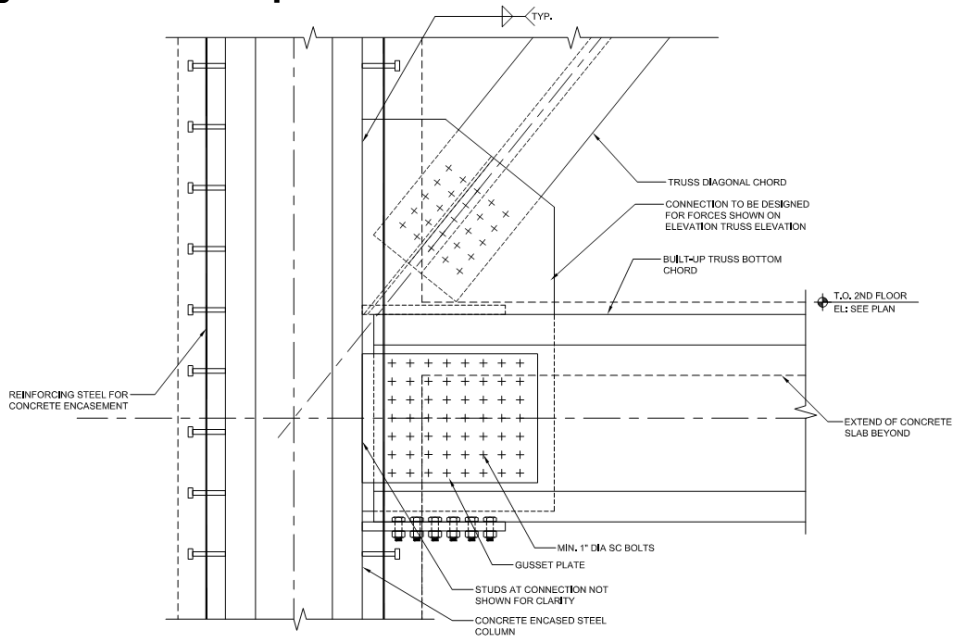
Drawing Details: Example 15



118

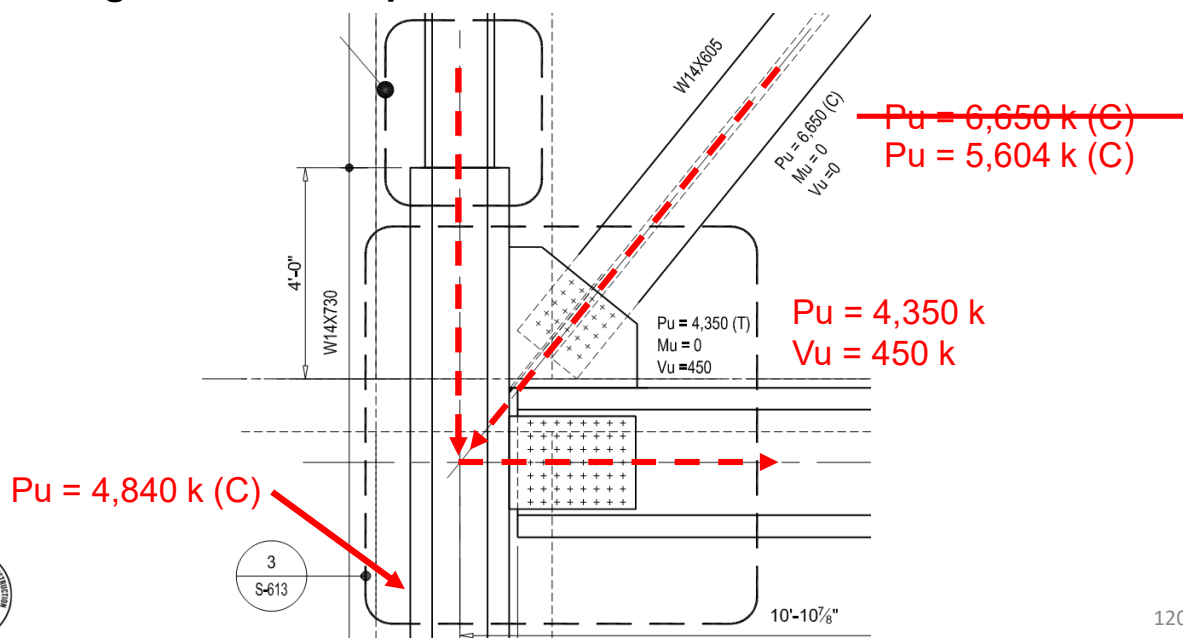


Drawing Details: Example 15



119

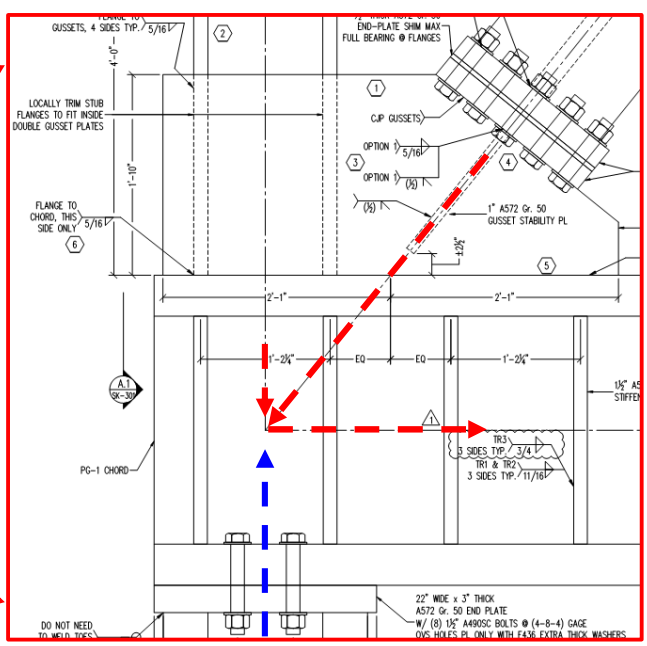
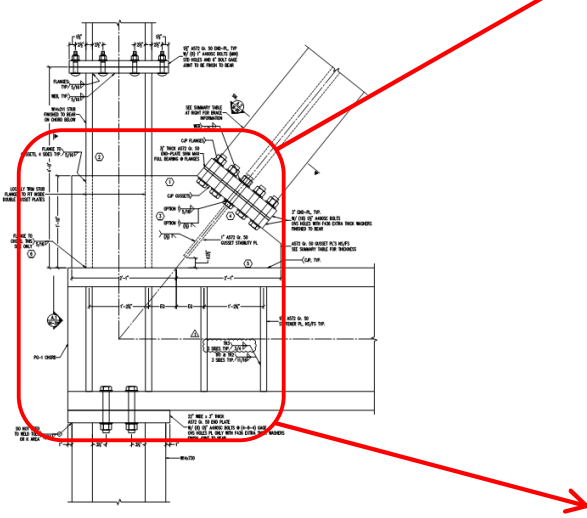
Drawing Details: Example 15



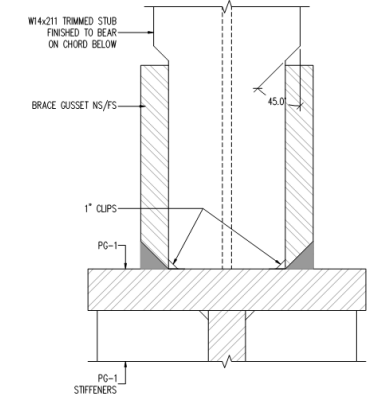
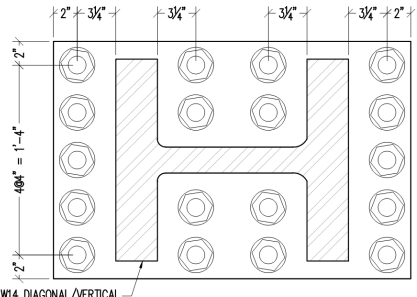
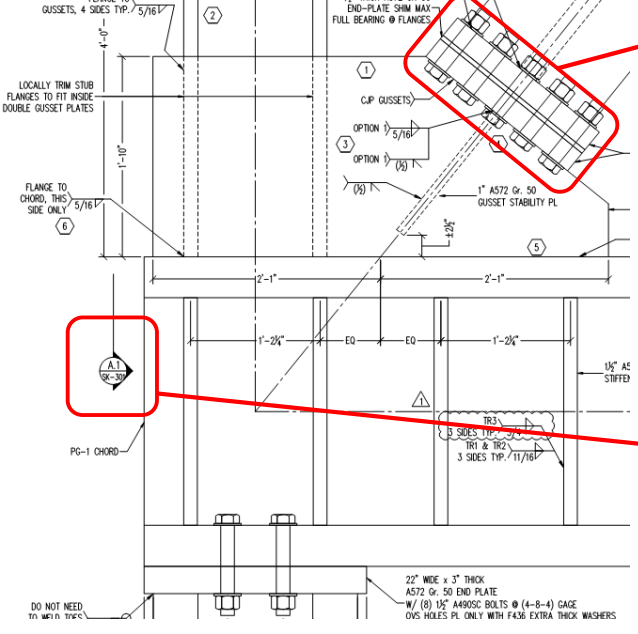
120



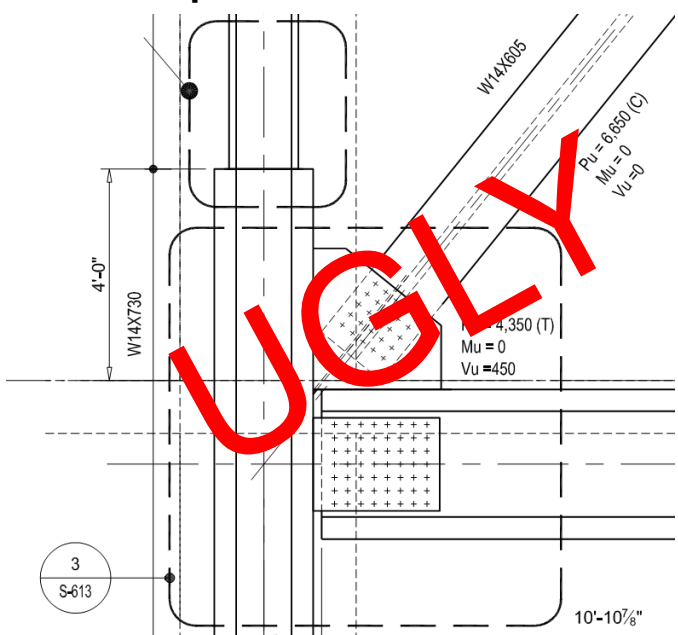
Drawing Details: Example 15



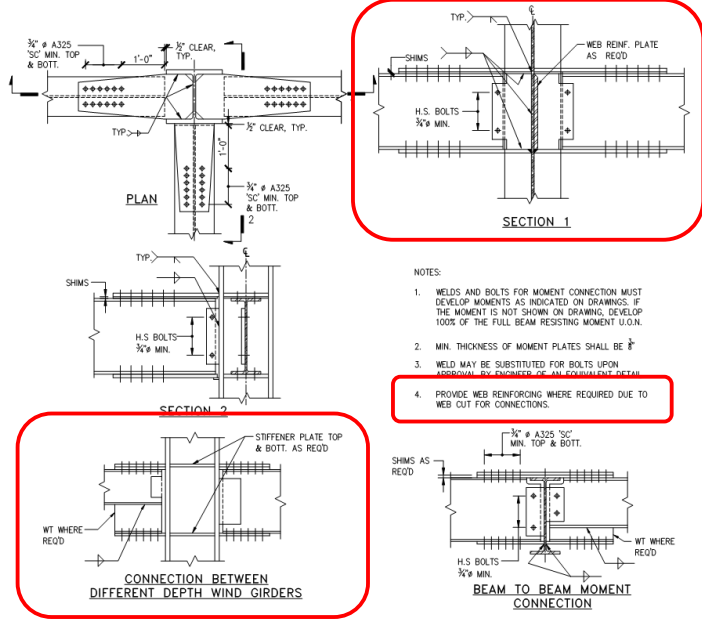
Drawing Details: Example 15



Drawing Details: Example 15



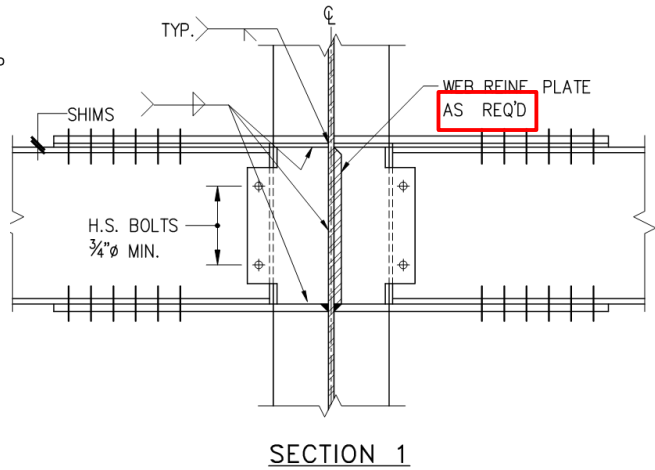
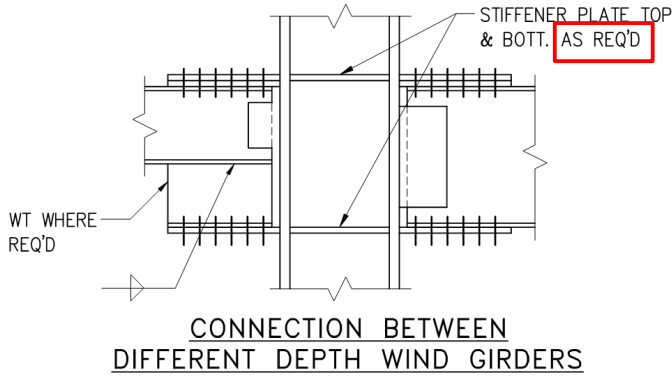
Drawing Details: Example 16



- NOTES:
1. WELDS AND BOLTS FOR MOMENT CONNECTION MUST DEVELOP MOMENTS AS INDICATED ON DRAWINGS. IF THE MOMENT IS NOT SHOWN ON DRAWING, DEVELOP 100% OF THE FULL BEAM RESISTING MOMENT U.O.N.
 2. MIN. THICKNESS OF MOMENT PLATES SHALL BE 1/2"
 3. WELD MAY BE SUBSTITUTED FOR BOLTS UPON APPROVAL BY ENGINEER OF AN EQUIVALENT DETAIL
 4. PROVIDE WEB REINFORCING WHERE REQUIRED DUE TO WEB CUT FOR CONNECTIONS.



Drawing Details: Example 16

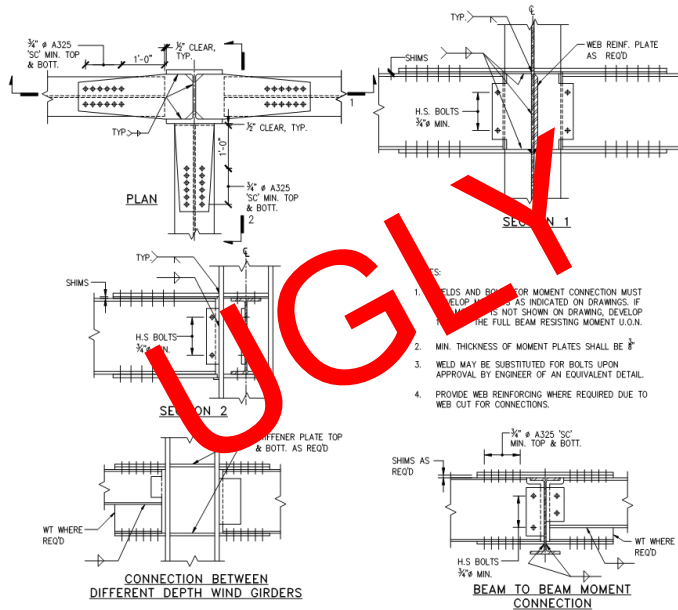


4. PROVIDE WEB REINFORCING WHERE REQUIRED DUE TO WEB CUT FOR CONNECTIONS.



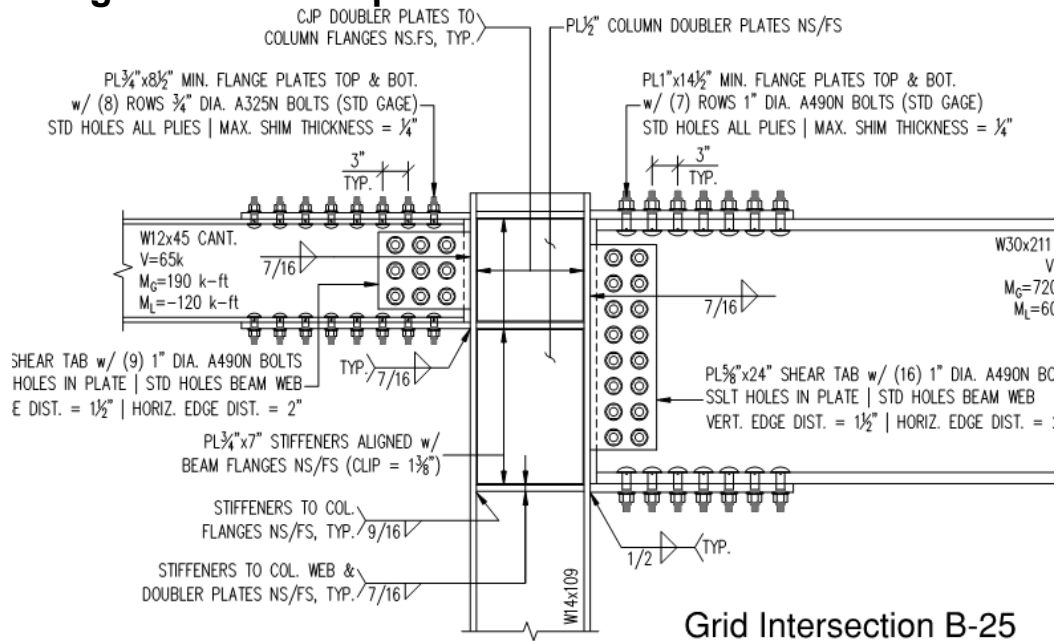
125

Drawing Details: Example 16



126

Drawing Details: Example 16



127

Drawing Details: Example 16

AISC Code of Standard Practice → Section 3.1.2

- At locations of connections, the following requirements shall apply to column stiffeners, web doubler plates, beam bearing stiffeners, and all other member reinforcement required to satisfy strength and equilibrium of forces through the connection....
 - Option 3A: member reinforcement at connections shall be designed by the owner’s designated representative for design
 - Option 3B: the owner’s designated representative for design shall provide a bidding quantity of items required for member reinforcement at connections with corresponding project-specific details that show the conceptual configuration of reinforcement appropriate for the order of magnitude of forces to be transferred. If no quantities or conceptual configurations are shown, member reinforcement at connections will not be included in the bid.

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Drawing Details: Example 16

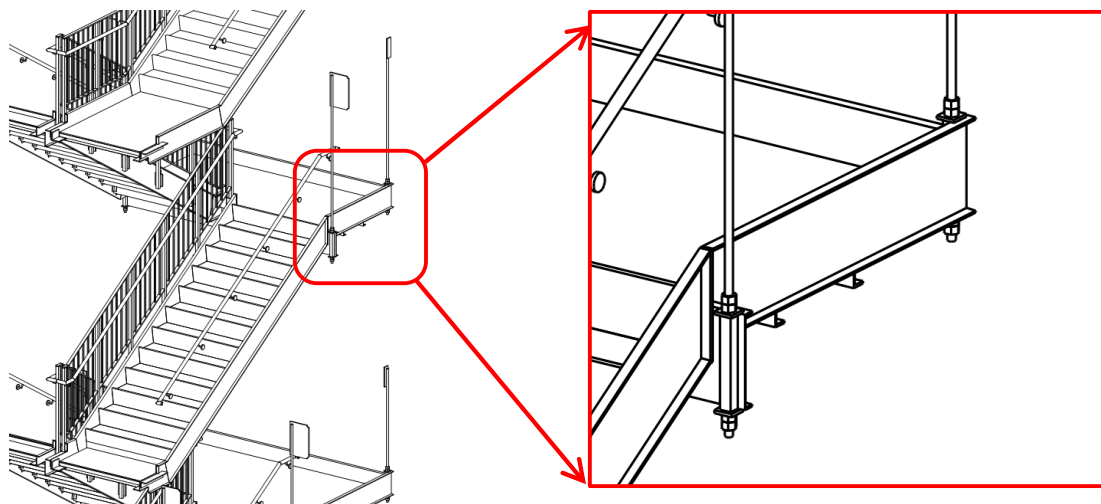
AISC Code of Standard Practice → Section 3.1.2

- When the actual quantity and/or details of any of the foregoing items differ from the bidding quantity and/or details, the contract price and schedule shall be adjusted equitably in accordance with Sections 9.4 and 9.5.



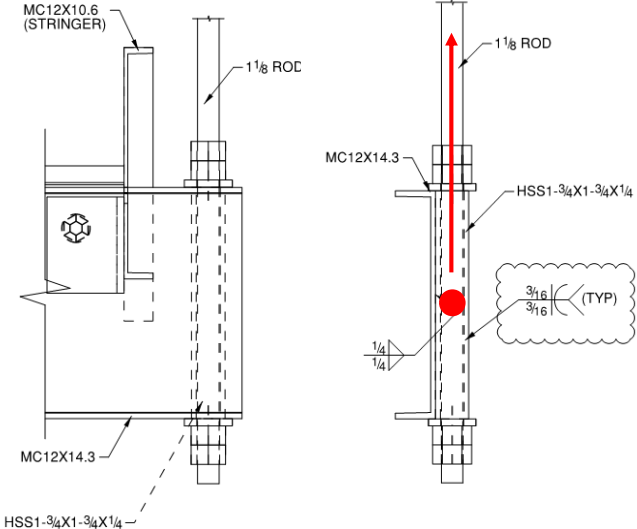
129

Drawing Details: Example 17

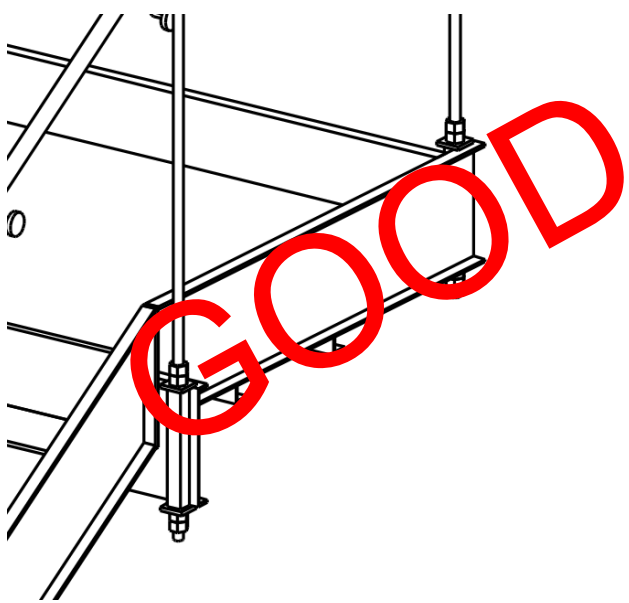


130

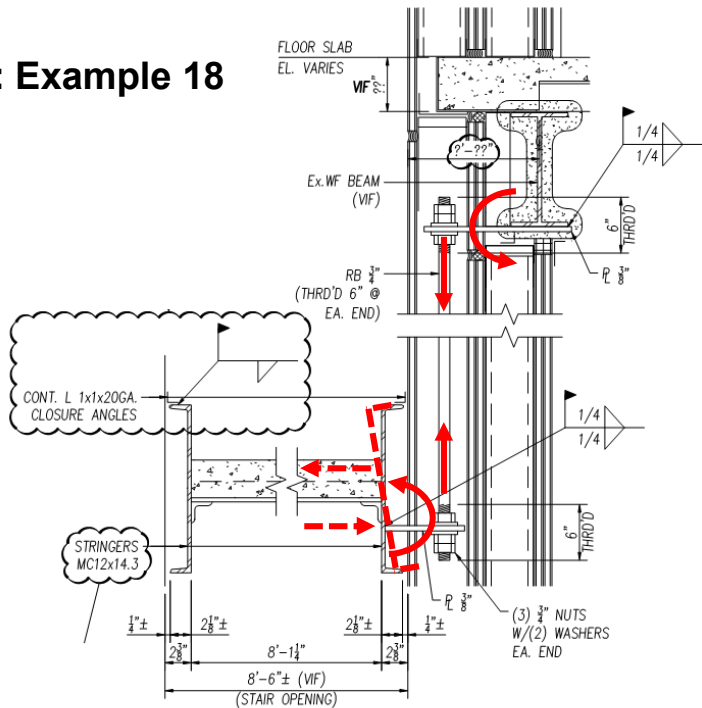
Drawing Details: Example 17



Drawing Details: Example 17



Drawing Details: Example 18

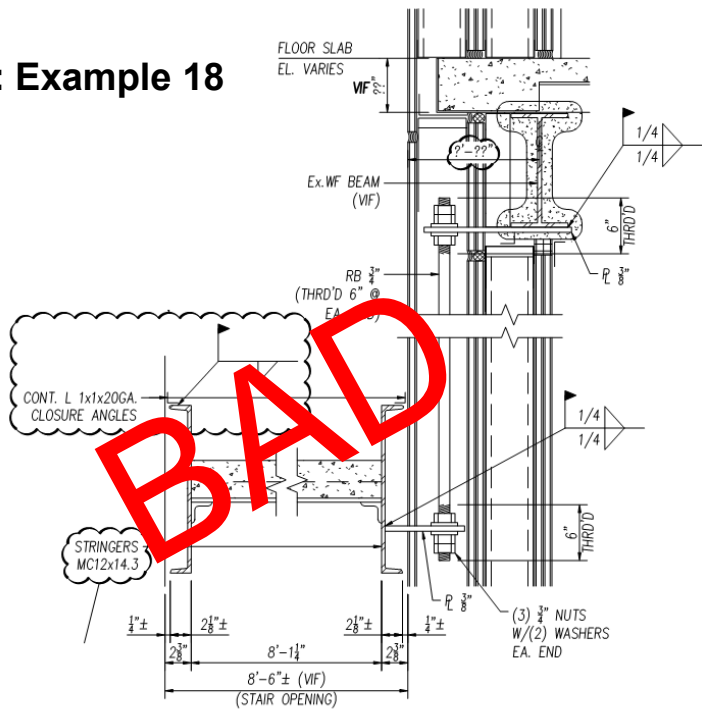


TYPICAL STAIR HANGER DETAIL

133



Drawing Details: Example 18

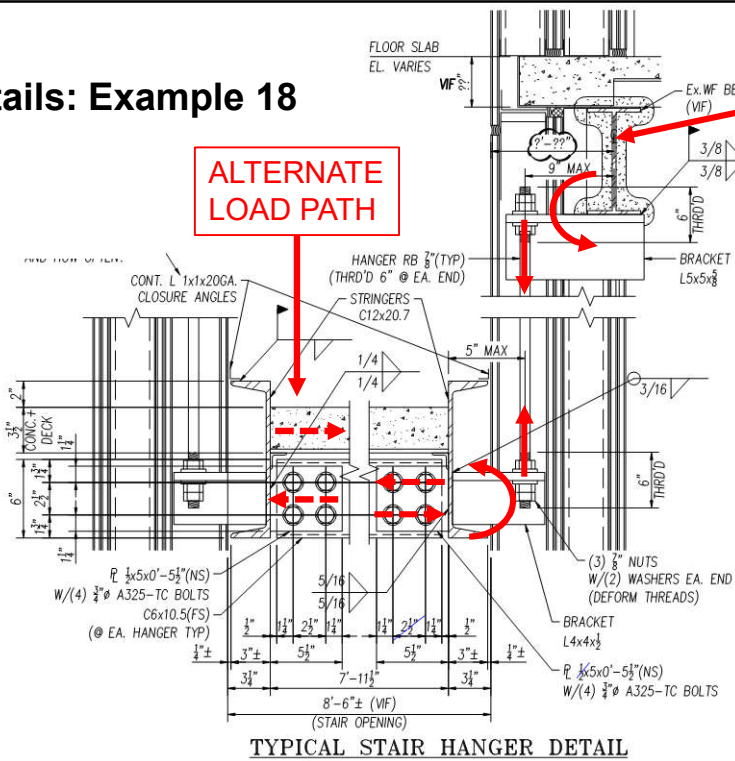


TYPICAL STAIR HANGER DETAIL

134



Drawing Details: Example 18



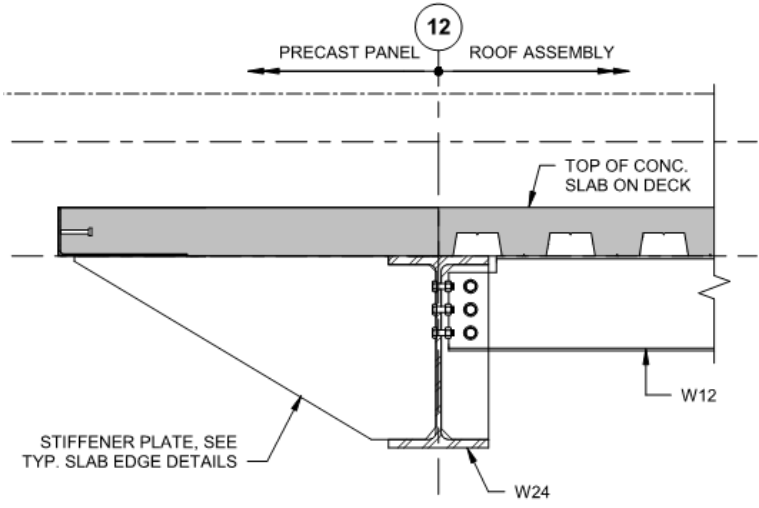
ALTERNATE LOAD PATH

EOR TO VERIFY EXISTING MEMBER WAS DESIGNED FOR ECCENTRIC LOADING. IF NOT, PROVIDE KICKERS, ETC.

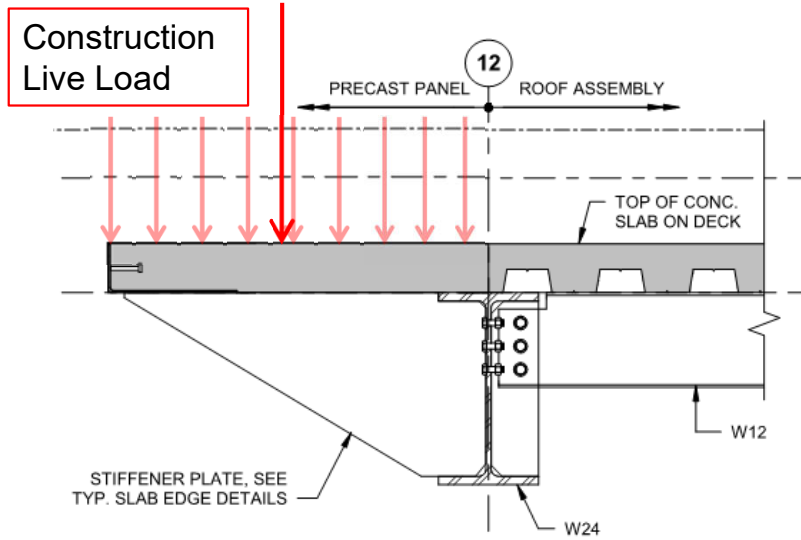


TYPICAL STAIR HANGER DETAIL

Drawing Details: Example 19



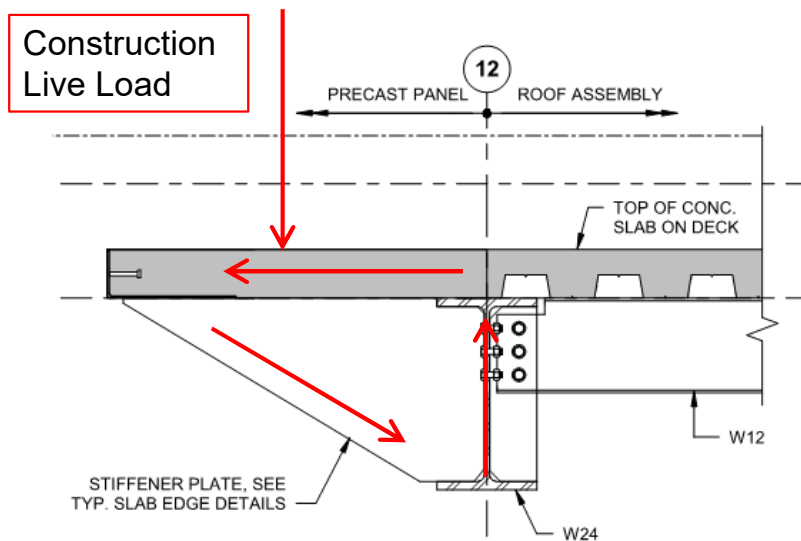
Drawing Details: Example 19



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Drawing Details: Example 19

Option 1:
Look at plate in
compression (strut-tie)



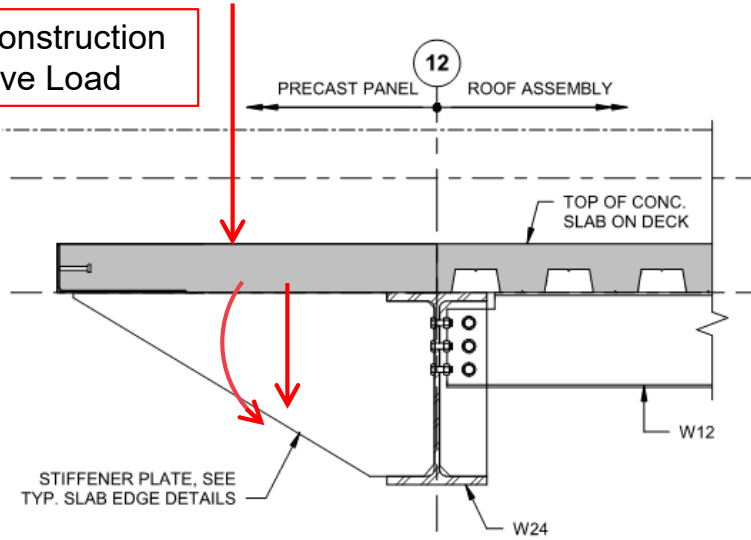
138



Drawing Details: Example 19

Option 2:
Look at plate in
bending and shear

Construction
Live Load

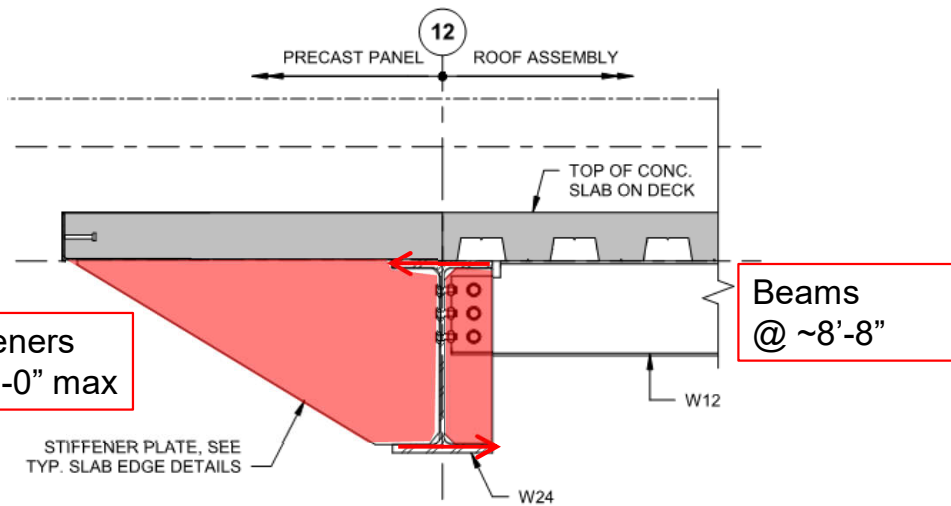


139

Drawing Details: Example 19

Stiffeners
@ 5'-0" max

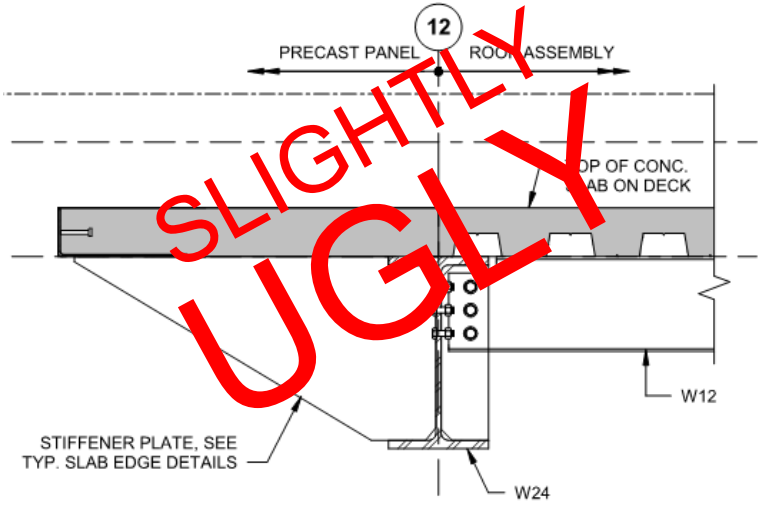
Beams
@ ~8'-8"



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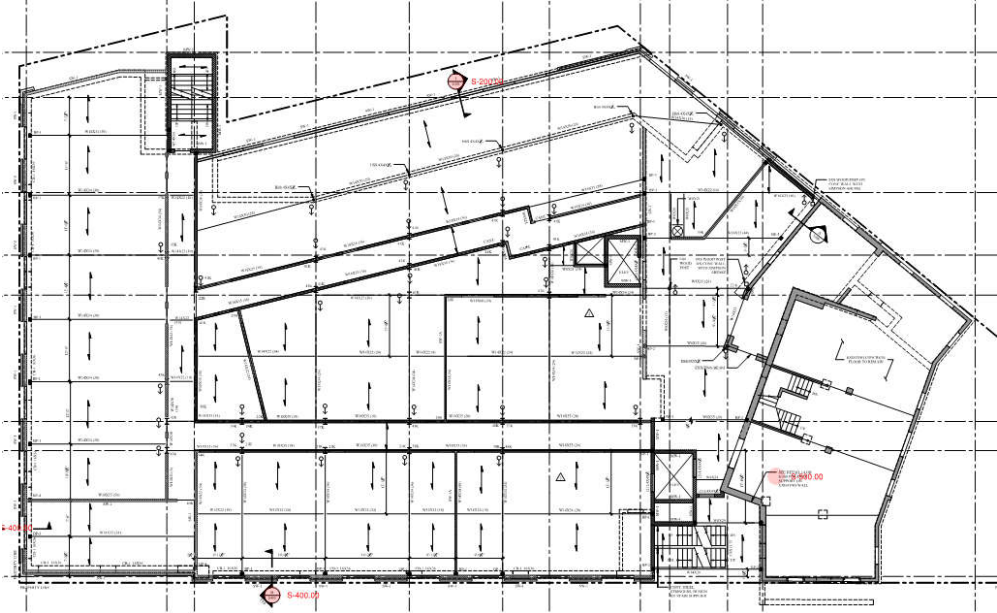


Drawing Details: Example 19



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Drawing Details: Example 20



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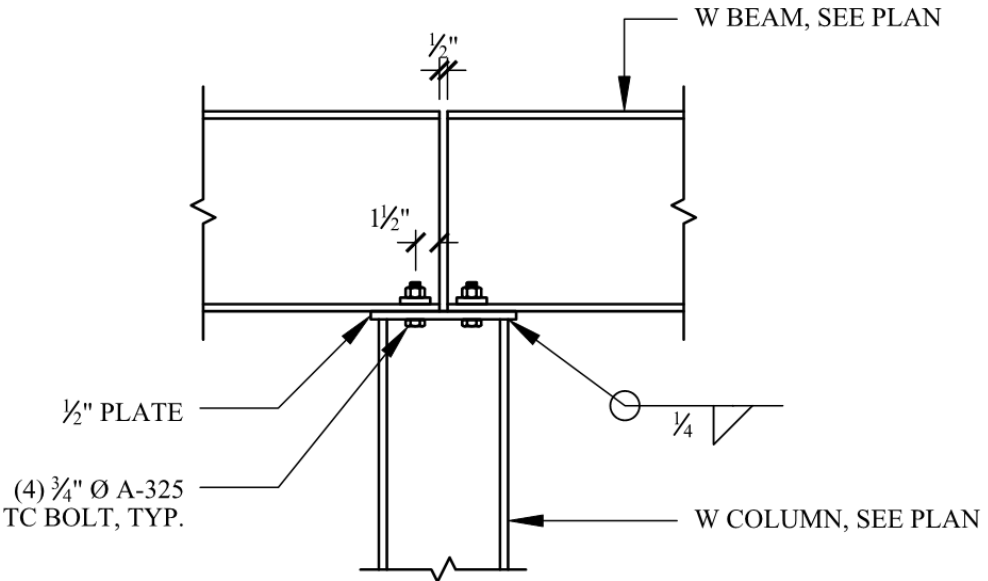


Drawing Details: Example 20



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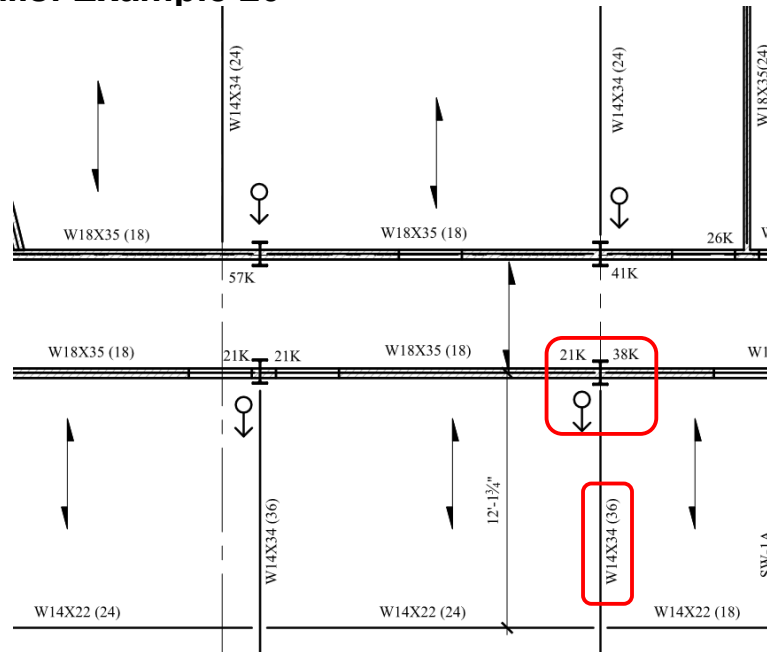
Drawing Details: Example 20



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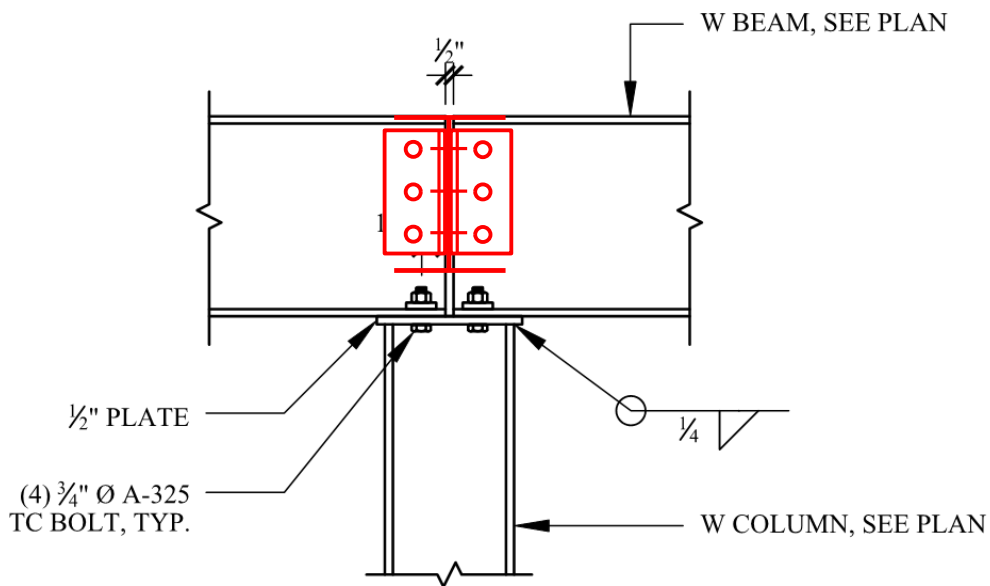


Drawing Details: Example 20



145

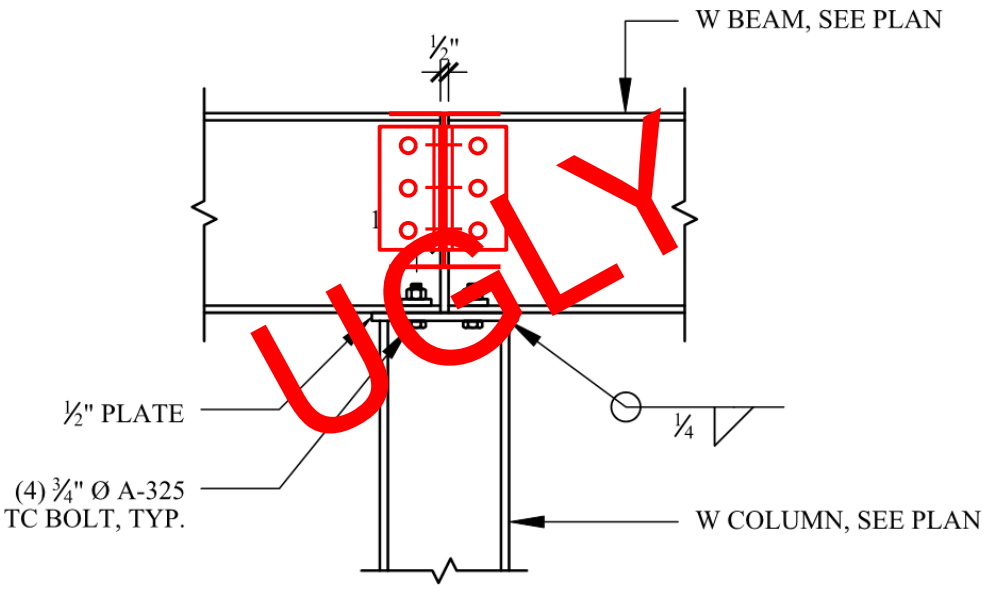
Drawing Details: Example 20



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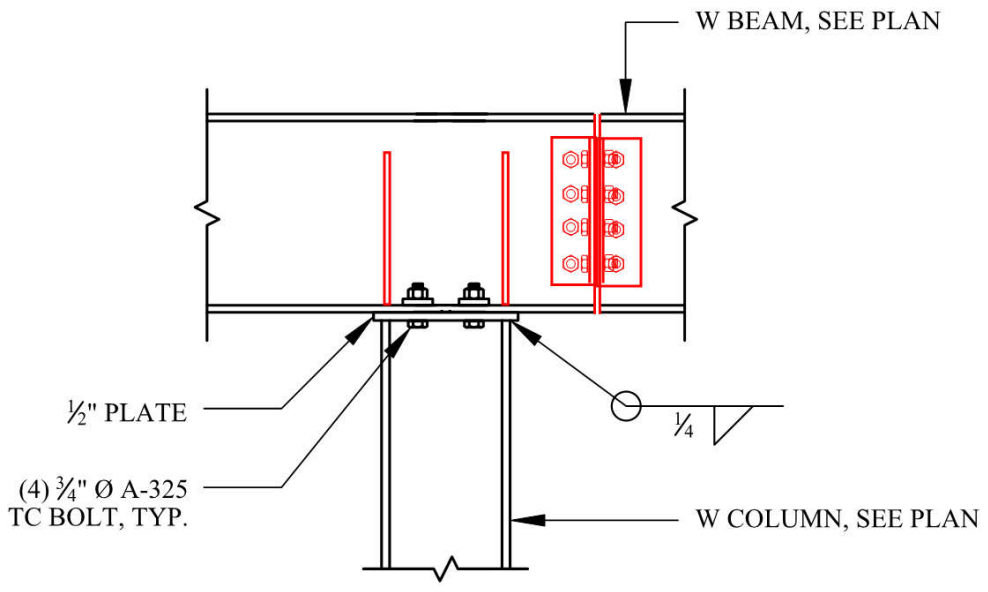
Drawing Details: Example 20



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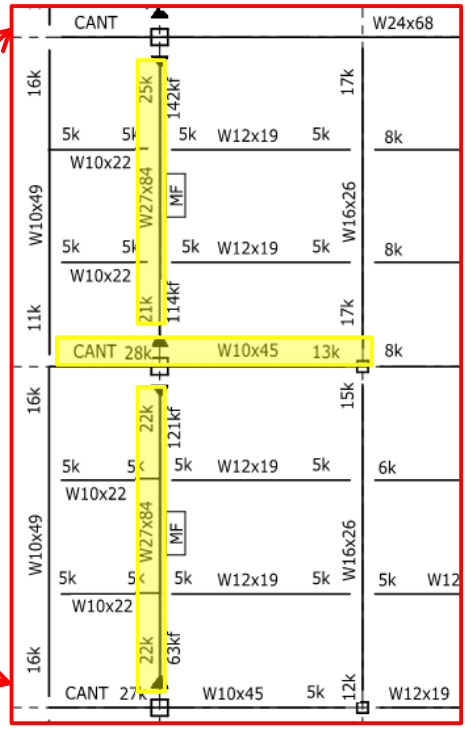
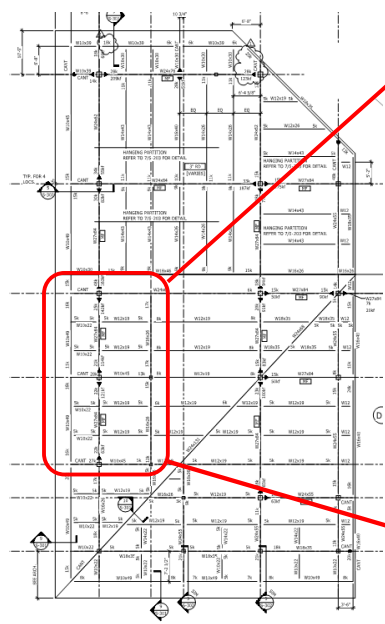
Drawing Details: Example 20



148

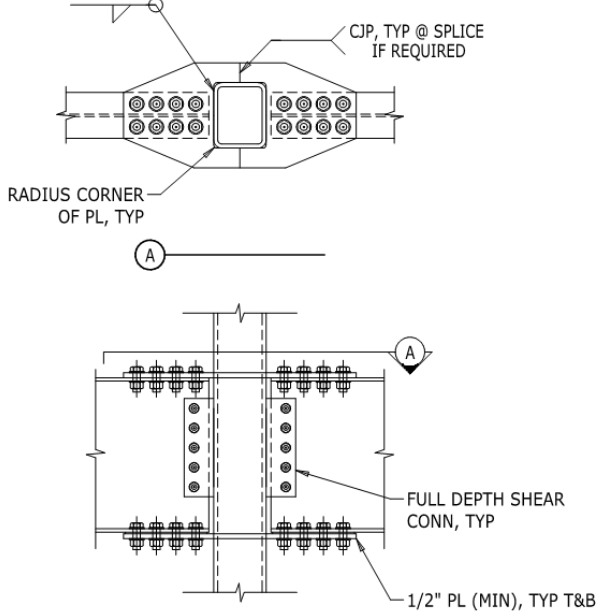
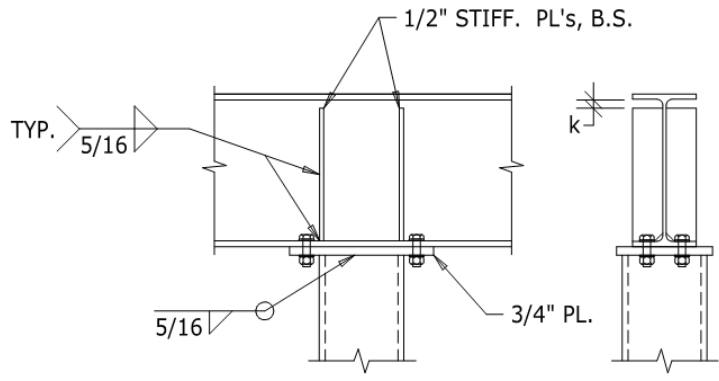


Drawing Details: Example 21



149

Drawing Details: Example 21



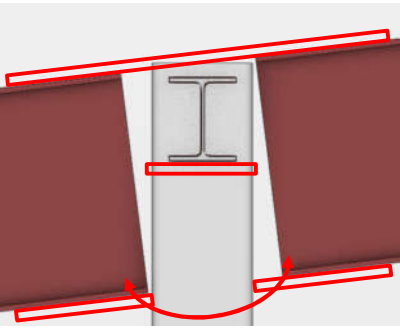
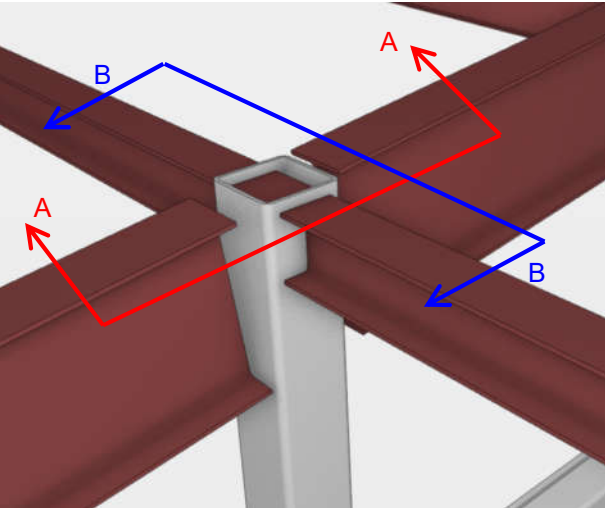
CONCEPT MOMENT CONNECTION SHOWN; CONNECTION DESIGN SHALL BE PER CONNECTION ENGINEER



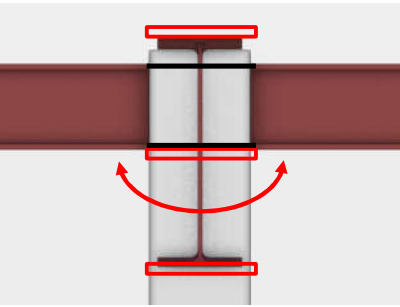
150



Drawing Details: Example 21



SECTION A-A

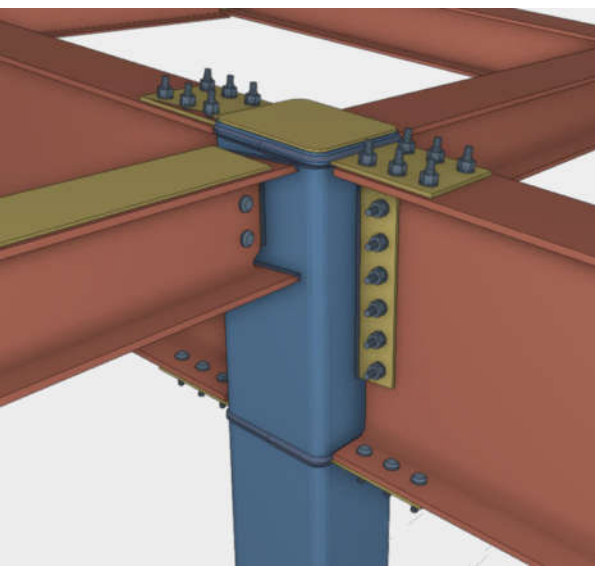
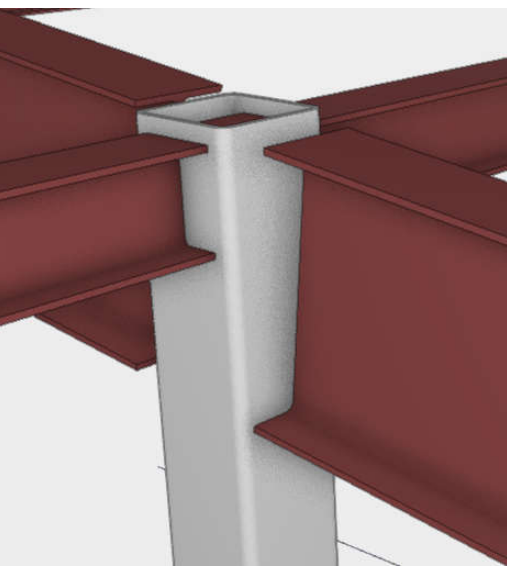


SECTION B-B

151



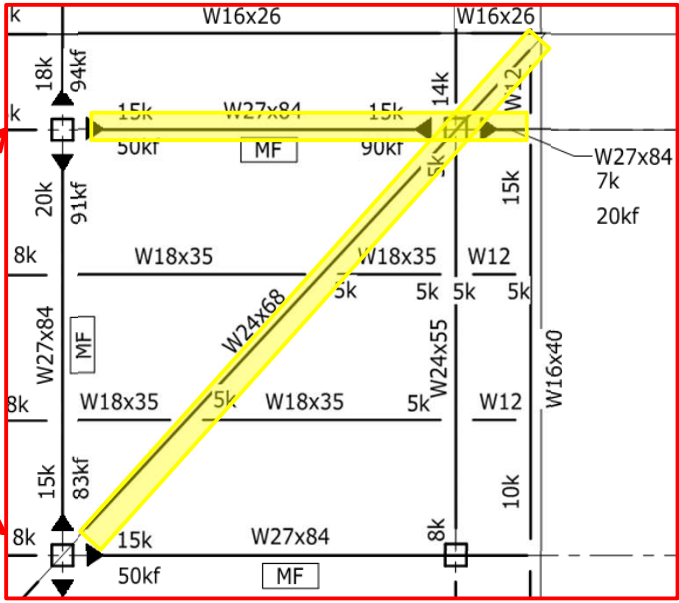
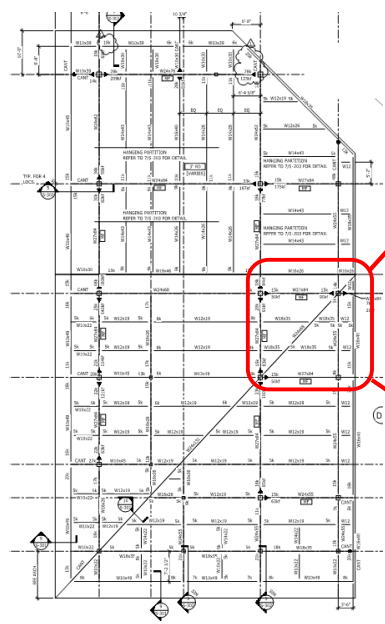
Drawing Details: Example 21



152

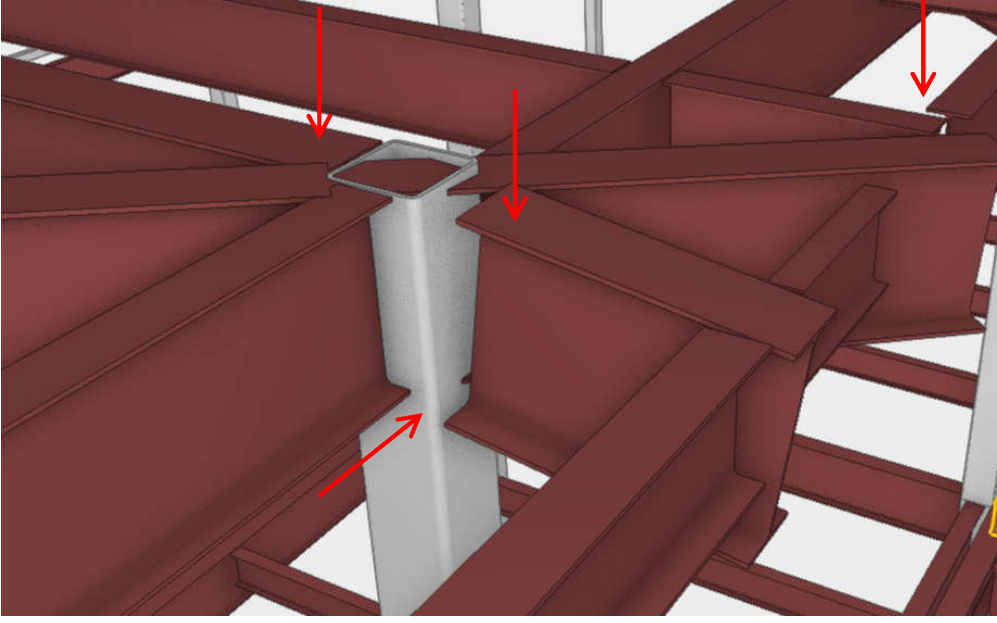


Drawing Details: Example 21



153

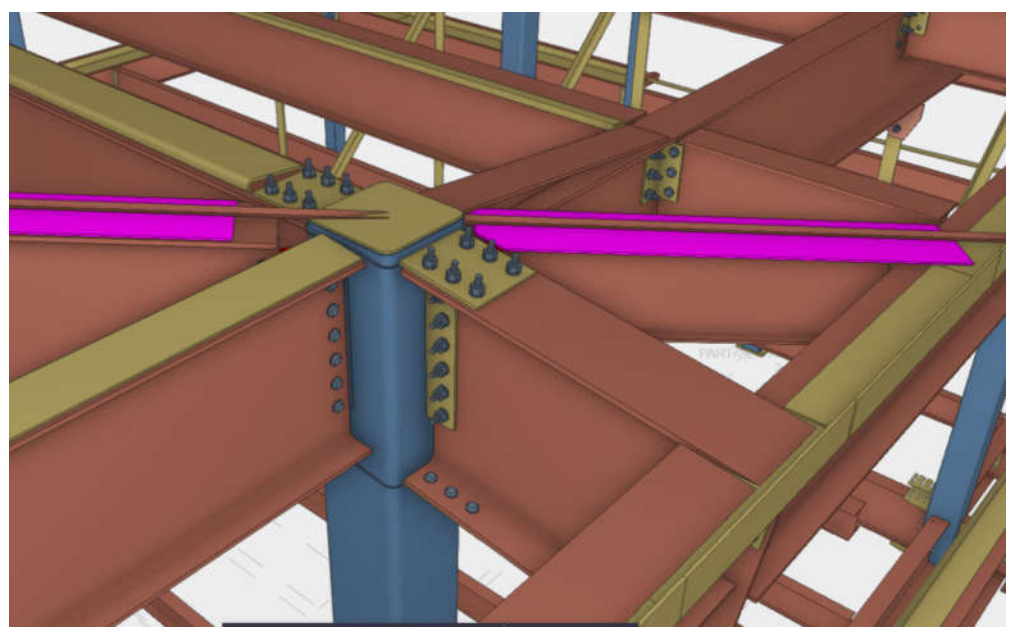
Drawing Details: Example 21



154

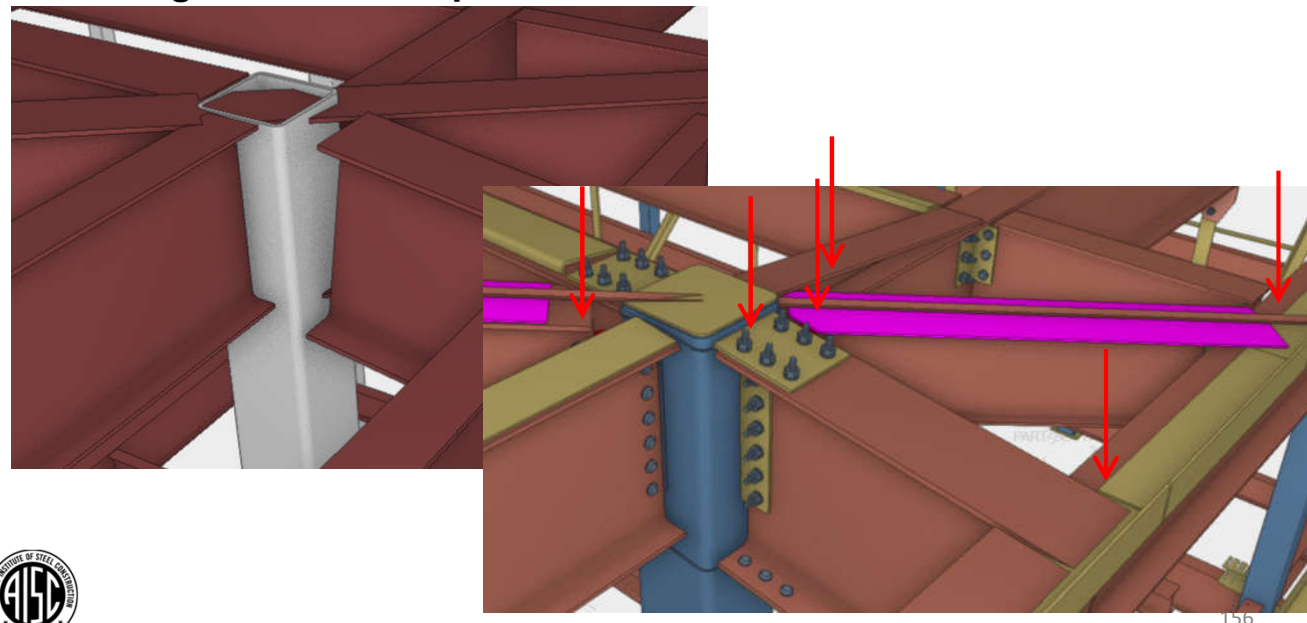


Drawing Details: Example 21



155

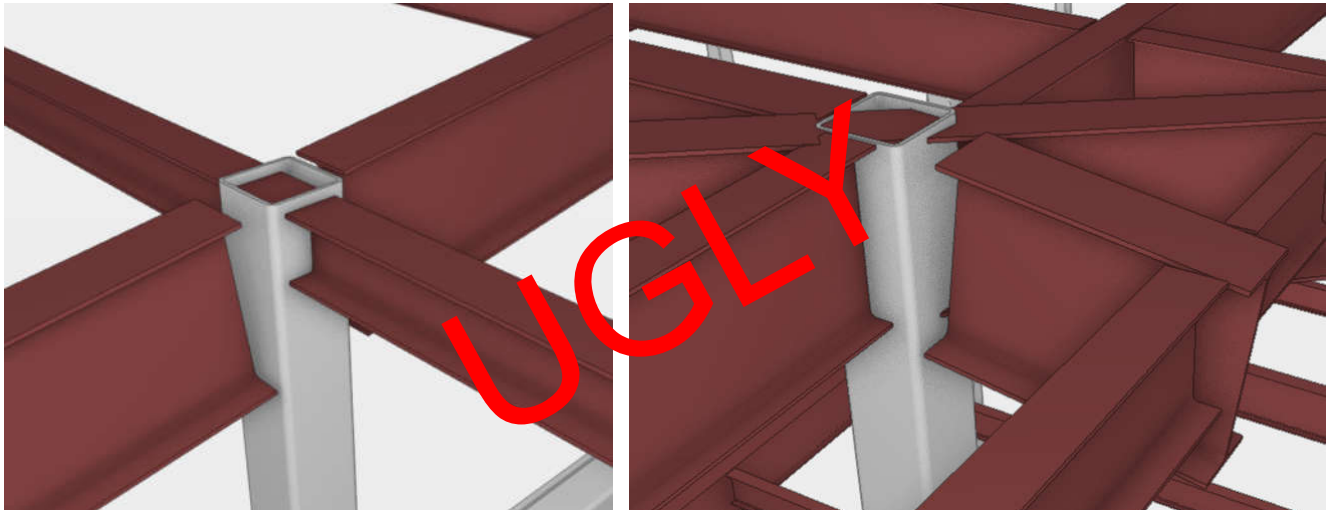
Drawing Details: Example 21



156



Drawing Details: Example 21



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Webinar Outline

- Introduction
- Define Good, Bad, Ugly Details
- Examples
- **Tips for Better Details & Connections**
- Assessment and Q/A



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Tips for Better Details & Connections

1. Follow the load path through the detail
 - If needed, cut the Free Body Diagram! (FBD)
2. Check all limit states
3. Be mindful of geometric layout and member selection
4. Follow AISC procedures and examples
5. Respect the SSE and Contractor's suggested detail alternates
6. Request (and SUPPLY) all "real" loads
7. Reminder: the SSE is NOT providing a peer review
8. Does it pass "The Eye Test?"



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Webinar Outline

- Introduction
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- Examples
- Tips for Better Details & Connections
- **Assessment and Q/A**



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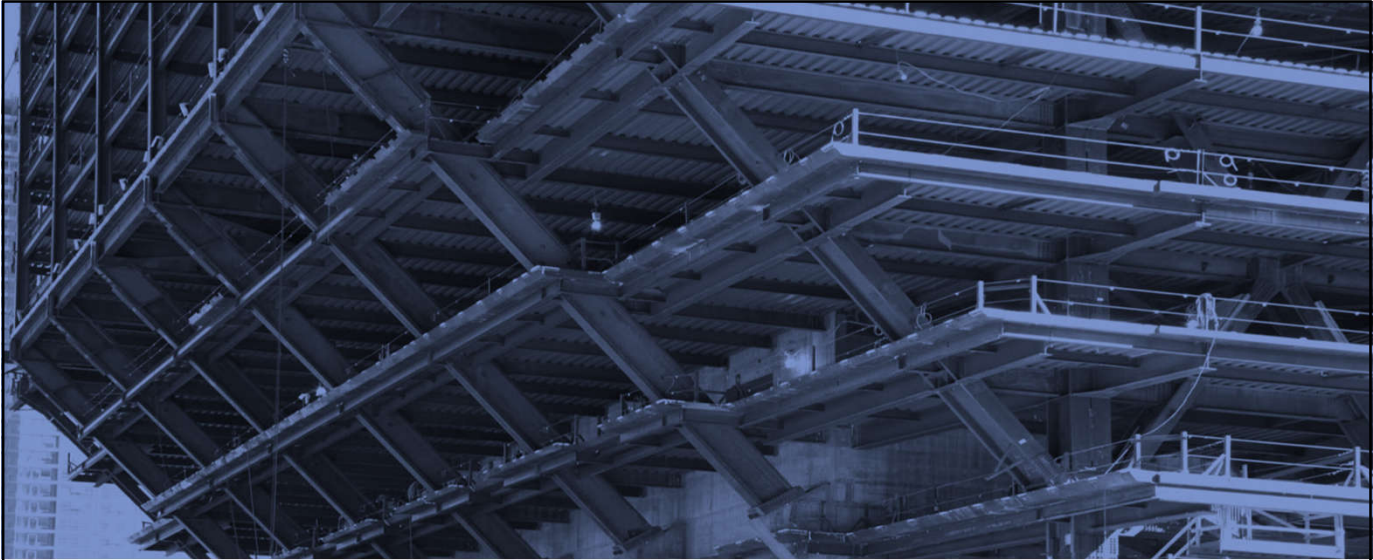
AISC | Questions?



PDH Certificates

- Reporting site (URL will be provided in the forthcoming email).
- Username: Same as AISC website username.
- Password: Same as AISC website password.





AISC | Thank you

